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# PROCEEDINGS

OF THE

# Royal Society of Victoria.

VOL. I. (NEW SERIES).

*Edited under the Authority of the Council.*

*ISSUED JUNE 1889.*

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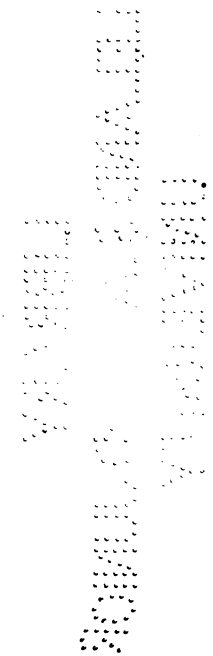

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# PROCEEDINGS.

# Art. I.—*On the Anatomy of an Arenaceous Polyzoon.*

By Arthur Dendy, M. Sc., F.L.S.

Demonstrator and Assistant Lecturer in Biology in the University of Melbourne.

[Read May 10, 1888.]

During the last Easter vacation I was enabled, through the kindness and hospitality of Mr. J. Bracebridge Wilson, to accompany him on several occasions while engaged in dredging operations at various localities near Port Phillip Heads. On one of these occasions we obtained a considerable quantity of a very remarkable arenaceous organism attached to the base of a mass of Ascidians. On my return to the University I examined my spirit-preserved specimens of this organism with some care, but without being able to elucidate its true nature. As it promised to prove of unusual interest I wrote to Mr. Wilson, asking him if he could send me some more specimens in a living condition. In consequence of my request Mr. Wilson devoted a considerable amount of time and trouble to again searching for the organism in question, and succeeded in a few days' time in sending me living specimens, not only of the species which I had previously obtained, but also of another quite distinct species of the same genus. These specimens reached me in excellent condition, and a glance at the living animal at once proved it to be a Polyzoon of very novel and peculiar form.

The genus, which is new to science, would appear to be not uncommon in Port Phillip, for Mr. Wilson informs me that he has been familiar with it for many years, and has often dredged it by the handful. He has also kindly suggested that, considering the difficulty experienced in determining its true character, the generic name *Cryptozoon* would not be inappropriate, a suggestion of which I am very happy to be able to avail myself.

I propose to call the species with which I first became acquainted *Cryptozoon wilsoni*, in honour of the well-known discoverer of this and many other new and remarkable

marine forms. The second species may be called *Cryptozoon concretum*, from the manner in which the sandy "nodes" have grown close together, with corresponding shortening of the chitinous internodes.

The new genus may be briefly diagnosed as follows:—"Ctenostomatous Polyzoa, with tubular, chitinous zoœcia enveloped in common aggregations of sand. Polypides provided with a muscular gizzard containing two horny teeth."

Before proceeding to describe the distinctive characters of the two species I will give a general account of the anatomy of the genus, so far as I have been able to work it out in such an unfavourable subject for investigation.

The chief difficulties in the way of a study of the soft tissues in *Cryptozoon*, consist (1) in the very minute size of the individual polypides; and (2) in the difficulty experienced in separating them from the mass of sand grains in which they are enveloped, and to which the zoœcia firmly adhere.

In the living animal I was able only to study the anatomy of so much as is protruded beyond the margin of the sandy mass when the animal is in a state of expansion (Fig. 1), that is to say, only the tentacles and a very small portion of the body, including the mouth and anus, together with the soft retractile portion of the zoœcium. Moreover, owing to the impossibility of separating the polypide in a living condition from the sandy mass, I could only examine it with a low power of the microscope.

Somewhat curious and more or less satisfactory results were obtained by teasing up with needles the masses of sand containing living polypides on a slide in a drop of sea water, then staining with carmine or magenta, and replacing the sea water by glycerine. After this process, there remains on the slide a quantity of more or less isolated sand grains, with here and there scattered about amongst them a polypide which has been forcibly torn from its zoœcium.

The most interesting point about this method is that the polypides are killed in an expanded condition, *i.e.*, with the lophophore expanded and the tentacles spread out at length, and separate from one another, instead of being all curved in and massed together in a compact bunch, as is the case in spirit-preserved specimens. Sometimes the lophophore, with the tentacles, is torn off from the remainder

of the polypide and can be examined from the surface, when it presents the appearance shown in Fig. 6.

The greater part of my observations were, however, made upon spirit-preserved material. Small portions of the zoarium, comprising several of the sandy masses, were stained *in toto* in borax carmine, according to the usual method. After dehydrating and clearing, the material was transferred to a slide and teased up with needles in a drop of balsam. The teased preparation was examined with a low power of the microscope, and it was possible with care to pick out the individual separated polypides on the point of a fine needle and mount them by themselves on fresh slides.

When a separate polypide was thus mounted it was possible, by carefully pushing the cover-glass with a needle, to roll it over into various positions, as might be required.

## The Cœnœcium.

The Cœnœcium is dichotomously branched, and the branches come off in several planes (Figs. 2, 3, 4.) It consists primarily of a slender chitinous tube. At fairly regular intervals, usually at each angle of the branching system, this tube breaks up suddenly into a number of very delicate tubular zoœcia, which are invested in a common sandy mass.

Thus the whole cœnœcium is divisible into what may be termed, for the sake of convenience, *nodes* and *internodes*. The nodes are dense aggregations of grains of sand, enveloping and firmly held together by the chitinous zoœcia (Figs. 1, 2, 3, 4, 5, N.) The internodes are longer or shorter, slender chitinous tubes, connecting the nodes together.

I have already mentioned that the cœnœcium, as a whole, is dichotomously branched. This results from the fact that whereas only a single tubular internode enters the lower surface of each arenaceous node, there are usually two such tubes originating from its upper surface. The branching, however, is not always a perfectly regular dichotomy; sometimes more than two internodes come out from the upper surface of a node. Thus in *Cryptozoon concretum* I have observed in one instance no less than six short tubes coming out from the surface of a terminal node, in addition to the internode on which it was supported. As the node

from which these six tubes originated was the terminal node of a branch, and probably had not as yet reached its full development, it is impossible to say how many of the six young tubes would have developed into perfect branches. Each one of them was short and had a rounded apex.

It is especially worthy of note that the tubular internodes are not continuous through the substance of the sandy nodes, but each one breaks up on entering the sandy mass into a kind of *rete mirabile*, formed chiefly of the delicate tubular zoœcia.

In *Cryptozoon wilsoni*, the type of the genus, the chitinous internodes are comparatively long, and the sandy nodes are well separated from one another. In *C. concretum*, however, the internodes are very much shortened, and the sandy nodes are brought close together, and in the older parts may even be confluent, forming a continuous sandy mass (cf. Figs. 2, 3 and 4).

The zoœcia are very delicate and adhere firmly to the sand grains, so that it is impossible to separate them. Perhaps in *Cryptozoon*, as in those horny sponges which take on an arenaceous habit, the chitinous portion of the skeleton is actually reduced in consequence of the addition of the sand, which may be considered as supplementing, and possibly, to a certain extent, replacing the chitin.

However this may be, it is very difficult to obtain an idea of the true shape and arrangement of the zoœcia. I can only say that they are tubular, and appear to spring one from another in an irregular manner (Fig. 11). The mouth of the zoœcium, as in all the Ctenostomata, remains soft and unchitinised, and, when the polypide is retracted, is pulled into the hinder part by a special series of muscular bands (Fig. 11, *m.*)

The points where the zoœcia arise from one another are marked by oval scar-like areas—the rosette plates (Fig. 11, *r.p.*)

The structure of the internodes of the cœnœcium may best be studied in *Cryptozoon wilsoni*. In that species they are short, somewhat dumb-bell-shaped tubes (Fig. 5 *Inn.*), with swollen extremities, breaking up suddenly on reaching the sandy node at either end into small, irregular branches, or giving rise directly to the zoœcia (Fig. 5). The wall of each internode appears in optical longitudinal section (Fig. 10), to be clothed internally with a deeply staining epithelium (*ep.*) I have not succeeded in demonstrating

with any degree of certainty the existence of nuclei in this layer, but there can be no doubt that it is composed of cells which secrete the chitinous wall of the tube. Very often this chitinous wall is roughened on its inner surface by minute, sharp prominences and ridges (Fig. 10, *p.*), which mark the points where secretion is most actively taking place. There can be no doubt that the epithelium lining the internodes is a direct continuation of the cœlomic epithelium of the polypides, and it appears to be the only organic connection between the different polypides of the colony.

## The Polypide.

The structure of the Polypide is essentially the same in both species. As much of it as can be made out in the living animal is represented in Fig. 1, while a more extensive view, such as is represented in Fig. 12, can only be obtained by teasing out the polypides in the manner already described.

The lophophore (Fig. 6) is of course circular. From its margin spring from 10 or 12 *(in C. wilsoni)* to 14 *(in C. concretum)* tentacles. Within the circle of tentacles are the mouth *(o)*, placed somewhat excentrically, and the nerve-ganglion *(n.g.)*, lying to one side of the mouth. The anus is outside the circle of tentacles, and is so placed that it lies in a line with the mouth and nerve-ganglion (Fig. 12).

The tentacles are hollow cylinders closed at their distal extremities. The wall of the cylinder, as already pointed out by Allman in the case of the fresh-water Polyzoa, is composed of two layers—an inner, apparently structureless layer (Fig. 7, *s. l.*), and an outer, epithelial layer. The epithelium does not present the same character all over the surface of the tentacle. Over the greater part of the surface it is composed of the ordinary, somewhat flattened, nucleated cells (Fig. 7, *ep.*), but on the in-turned face of each tentacle there are two parallel longitudinal rows of small columnar cells (Fig. 7, *c. c.*), each containing a relatively large, deeply-staining nucleus.

When the tentacles are examined in the living condition each one is seen to possess two rows of vibratile cilia, projecting on each side beyond its margin. Each cilium is nearly as long as the tentacle is thick, and they always move in a perfectly definite and regular manner, although detachments of them are capable of temporarily ceasing

their movement, while the remainder go on. If we imagine the inner face of the tentacle to be anterior and the outer posterior, the cilia are seen always to move upwards on the right hand side and downwards on the left.

Although I have not succeeded in observing the cilia in my mounted preparations, yet we may with safety conclude that they are definitely related to the two longitudinal rows of columnar cells just described, and that each of these cells bears a single cilium as represented in Fig. 7.

The alimentary canal is very complex, and we can distinguish no less than five perfectly distinct regions, viz., *pharynx, œsophagus, gizzard, stomach,* and *intestine.*

The mouth, as already observed, is excentrically placed within the circle of tentacles (Fig. 6, *o.*) It leads directly into a dilated pharynx lined by columnar cells (Fig. 12, *ph.*) The inner surface of the pharynx, *i.e.*, that turned towards the stomach, is more strongly curved than the outer surface, and the constriction at the lower end of the pharynx, which separates it from the œsophagus, is formed chiefly by a deep inward fold of the inner surface. A sharp re-entrant angle is thus formed, and over this angle the columnar epithelium is higher than elsewhere.

The œsophagus (Fig. 12, *œ.*) is a simple, thin-walled, saccular organ, interposed between the pharynx and the gizzard.

The gizzard (Fig. 12, *giz.*) is certainly the most remarkable portion of the whole alimentary canal. It is globular in shape and has thick muscular walls, consisting mainly of a stout circular band of muscles (Fig. 8, *c. m. b.*; Fig. 12, *c. m. b.*), oval in section and composed of a great number of delicate fibres, surrounding two relatively large chitinous teeth (*t.*) The teeth are squarish in shape, and flattened. They are planted within the muscular mass in such a manner that their broad surfaces lie parallel with the plane of the loop of the alimentary canal. This arrangement will be best understood by reference to Figs. 8 and 12.

The gizzard opens directly into the side of a very large, elongated, saccular stomach, of the shape shown in Figs. 9 and 12. The stomach is differentiated by the character of its lining membrane into two totally distinct regions—an upper, non-digestive, and a lower, digestive portion. The upper portion, next to the intestine, is lined, like the pharynx, by columnar epithelium, and the cells of this epithelium are ciliated (Fig. 9, *c. e., cil.*) At about the upper level of the

opening of the gizzard the walls of the stomach thicken, and the single layer of columnar cells gives place to several layers of spherical cells (Fig. 9, *s. c.*), containing yellow granules. As was the case in the pharynx the walls of the digestive part of the stomach are thicker in certain places than elsewhere, as shown in the figures.

In *Cryptozoon concretum* (Fig. 9) the difference between the digestive and non-digestive portions of the stomach is more strongly marked than in *C. wilsoni*, and it is in the former species alone that I have succeeded in detecting the cilia at the upper end, although there is no reason to doubt that they occur also in the latter. It should be noted, that these cilia are also figured by Allman in certain fresh-water forms.

A rather narrow aperture (Fig. 9, *o. i.*) places the upper end of the stomach in direct communication with a saccular, very thin-walled intestine (Fig. 12, *int.*), terminating at the anal opening (*a.*), the position of which, outside the circle of tentacles, has already been indicated.

The entire alimentary canal, which in all Polyzoa has the form of a loop, is clothed externally by a delicate, closely-fitting, flattened epithelium—the cœlomic epithelium (Fig. 9, *ep.*; Fig. 12, *n. e.*), the nuclei of which are plainly discernible over the greater part of its surface. On the intestine, these nuclei are in places elongated in the transverse direction, and this takes place especially in the region just opposite to the nerve ganglion, giving rise to a deceptive appearance of columnar epithelium in this locality.

To the lower portion of the stomach is attached the funiculus or posterior mesentery (Figs. 11 and 12, *fun.*) in a perfectly normal manner.

The muscular system is well developed. There are:—(1) A circle of short retractor muscles (Fig. 11, *m.*) attached above to the introversible portion of the zoœcium. Of these muscles, each of which is composed of a band of simple fibres, I have counted four, and they appear to be all attached at the same level. It is possible that a fifth occurs, but has escaped notice owing to its being hidden behind the others; (2) A broad band of long fibres (Fig. 11, *r. m.*; Fig. 12, *m.*) attached above in a semi-circle just beneath the bases of the tentacles, around the margin of the lophophore remote from the anus. These fibres converge below to a point (Fig. 11, *a. m.*) deep down on the near side o the wall of the zoœcium. This band is the great retractor muscle of

the polypide, by means of which it can be withdrawn right inside the zoœcium, as in Fig. 11. Each of the long muscle fibres (Fig. 12, *m. f.*) appears to consist of a single cell, and at a point about the middle of each there is an oval swelling; here the fibre stains more deeply than elsewhere, and this spot must doubtless be regarded as the position of the nucleus (Fig. 12, *n. m. f.*)

All that I have been able to observe concerning the nervous system of Cryptozoon is the presence of an oval ganglion, situated in the usual position between mouth and anus.

So far as I am aware, Cryptozoon is the only Polyzoon which makes use of sand in the formation of its skeleton, and it is interesting to find a Polyzoon acquiring a habit with which we are already familiar in other groups, such for example, as Foraminifera, Sponges, and Annelids. The genus is obviously closely allied to *Bowerbankia*, as is shown by the presence of the gizzard, and the aberrant structure of its cœnœcium may perhaps be best understood by comparison with that genus. In *Bowerbankia pustulosa*, for example, the cœnœcium is entirely chitinous. It branches dichotomously, and at each angle of the ramification there is a close-packed group of tubular zoœcia. We have only to imagine these zoœcia to become more irregularly and diffusely arranged and invested in a common sandy matrix, beyond the surface of which the tentacles are protruded, and we shall arrive at the condition of *Cryptozoon*. Cryptozoon, therefore, may be regarded as a *Bowerbankia*, which, for the sake of additional protection, has acquired the habit of agglomerating particles of sand on to the zoœcia.

It might perhaps even be doubted whether there exist sufficient differences to separate *Cryptozoon* from *Bowerbankia*, but the fact that there are at least two totally distinct species which form arenaceous nodes seems to me to render desirable the erection of a new genus.

I will now briefly enumerate the distinctive characters of the two species.

### Cryptozoon wilsoni.

The zoarium (Figs. 2, 3) forms dense, bushy masses attached to foreign objects. Sometimes it appears to be provided with a common basal agglomeration of sand

particles, but sometimes it springs direct from the substratum on which it grows.

It is, as a rule, dichotomously branched, and the branches come off in many planes. The ramification is very profuse, which gives to the whole colony a reticulate appearance, but I have not succeeded in detecting any actual anastomoses.

The fully grown sandy nodes are spherical, and usually about 1 mm. in diameter. They are perfectly distinct from one another, and the internodes are well developed, being a little shorter than the diameter of the nodes. The terminal, young nodes are much smaller than the older, fully grown ones.

The polypides have up to 12 tentacles, although sometimes it is possible to count only 10 or 11. In the living animal the fully expanded tentacles are about 0·2 mm. long.

In one slight varietal form (Fig. 3) the nodes are somewhat larger and nearer together than in the typical form. It is this slight variety which I was able to examine in the living condition, and from which the anatomical figures are drawn.

### Cryptozoon concretum.

The zoarium (Fig. 4) forms dichotomously branched tree-like masses, provided with a common sandy base. The entire growth is very much coarser than in *C. wilsoni*, and the branching, which takes place in several planes, is less copious and intricate. Sometimes, but only rarely, the branches appear to form anastomoses.

The internodes are reduced almost to nothing, and the nodes usually touch one another, or are actually fused together. It is only in the upper, younger portions of the colony that separate spherical nodes can be distinguished. In the lower, basal portions, they fuse together into common, stem-like, sandy masses. The diameter of a stem, near the base of a colony and above the basal expansion, is about 2 mm.; while the nodes which are in process of fusion and still separate gradually decrease in diameter as they approach the ends of the branches. The polypides are larger than in *C. wilsoni*, their tentacles being 0·3 mm. long in the fully expanded, living animal. The number of the tentacles is 14. The differentiation of the stomach, into digestive and non-digestive regions, is somewhat more strongly marked than in *C. wilsoni*.

## DESCRIPTION OF PLATES.

### PLATE I.

Fig. 1. A node of *Cryptozoon wilsoni*, with the polypides alive and their tentacles protruding from between the grains of sand. Owing to the manner in which the node is viewed the polypides are visible only around the margin, though, of course, occurring all over the surface. (*pop.*) Projecting portion of polypide. (*s.g.*) Sand grains. (*Inn.*) Chitinous, tubular internodes.

Fig. 2. Portion of cœnœcium of *Cryptozoon wilsoni*, more typical form. x 10. (*N.*) Nodes. (*Inn.*) Internodes.

Fig. 3. Portion of cœnœcium of *Cryptozoon wilsoni*, larger variety. x 4. (*N.*) Nodes. (*Inn.*) Internodes.

Fig. 4. Cœnœcium of *Cryptozoon concretum*. x 4. (*B.e.*) Basal expansion. (*N.*) Nodes. (*Inn.*) Internodes, in this case almost entirely suppressed.

### PLATE II.

Fig. 5. A tubular internode of *Cryptozoon wilsoni*, separated by teasing, with a number of sand grains, held together by the chitinous branches and the zoœcia, still adherent at either end. (*Inn.*) Internodes. (*s.g.*) Sand grains. (*ch.*) Remains of chitinous branches and zoœcia, cementing the sand grains together.

Fig. 6. Lophophore of *Cryptozoon concretum* seen from above; from a specimen teased up alive. (*o.*) Mouth. (*n.g.*) Nerve ganglion. (*ten.*) Tentacles (bases only represented).

Fig. 7. Diagrammatic longitudinal section of a portion of a tentacle of *Cryptozoon*, passing through one of the longitudinal rows of columnar ciliated cells. (*can.*) Central canal. (*s. l.*) Inner structureless lamella. (*ep.*) Ordinary epithelium. (*c. c.*) Columnar cells. (*ci.*) Cilia.

Fig. 8. Diagrammatic section through the gizzard of *Cryptozoon*, showing the chitinous teeth implanted in the muscular mass. The section is supposed to pass through the two openings of the gizzard, and at right angles to the plane of the paper in Figs. 11 and 12. (*c. m. b.*) Sections of circular muscle band. (*t.*) Sections of chitinous teeth.

Fig. 9. Optical longitudinal section through the stomach of *Cryptozoon concretum*, passing through its two

Fig 1

Fig 4 x 4.

Fig 2 x 10.

Fig 3 x 4.

openings, and showing the differentiation into non-digestive region above and digestive region below. (*o. g.*) Opening from gizzard. (*o. i.*) Opening into intestine. (*ep.*) The cœlomic epithelium, which invests the entire alimentary canal. (*c. e.*) Columnar epithelium of the upper, non-digestive portion of the stomach. (*cil.*) Cilia of the columnar, nucleated cells. (*s. c.*) Spherical cells containing yellow granules, forming the wall of the lower, digestive portion of the stomach.

Fig. 10. Optical longitudinal section through the wall of an internode of *Cryptozoon wilsoni*. (*chi.*) Chitinous wall, raised here and there into angular prominences—(*p.*). (*e.p.*) Deeply staining epithelium clothing the inner surface of the tube.

Fig. 11. A tubular zoœcium of *Cryptozoon wilsoni*, containing a retracted polypide. The zoœcium has been separated by teasing, but portions of other zoœcia are still adherent on the right-hand side, and two sand grains are still attached near the mouth of the zoœcium. (*s. g.*) Sand grains. (*w. z.*) Wall of zoœcium. (*inv.*) Invaginated portion of zoœcial wall. (*mo.*) Mouth of zoœcium. (*m.*) Retractor muscles of invaginated portion of wall of zoœcium. (*r. m.*) Retractor muscle of polypide. (*a. m.*) Attachment of retractor muscle to wall of zoœcium. (*r. p.*) Rosette plates, indicating where other zoœcia have been attached. (*ph.*) Pharynx. (*œ.*) Œsophagus. (*giz.*) Gizzard. (*st.*) Stomach. (*int.*) Intestine. (*b. b.*) Brown body (?). (*fun.*) Funiculus. (*n. g.*) Nerve ganglion.

## PLATE III.

Fig. 12. A polypide of *Cryptozoon wilsoni* separated from the zoœcium by teasing, and seen from the side as a transparent object. (*ten.*) Tentacles. (*ph.*) Pharynx. (*œ.*) Œsophagus. (*giz.*) Gizzard. (*st.*) Stomach. (*int.*) Intestine. (*fun.*) Funiculus. (*a.*) Anus, represented open for the sake of clearness, though normally closed. (*n. g.*) Nerve ganglion. (*m. f.*) Fibres of retractor muscle. (*n. m. f.*) Nuclei of muscle fibres. (*t.*) Horny tooth of gizzard. (*c. m. b.*) Circular muscle of gizzard seen in section. (*n. e.*) Nuclei of the cœlomic epithelium investing the alimentary canal.

## Art. II.—*The Maintenance of Energy.*

By Robt. Abbott, Esq., Licensed Surveyor.

[Read April 12, 1888.]

In course of a conversation with Mr. J. P. Thomson over twelve months ago, I mentioned to him that I held different views respecting the nature and causes of volcanic action, and of elevation and subsidence, to those usually accepted. Mr. Thomson was then good enough to ask me to contribute a paper to your Society setting forth these views. I have since been collecting materials. The theories I hold depend almost entirely on the action of a force which I venture to think has not received the attention it merits. I propose to devote this short paper chiefly to the consideration of the form of energy in question.

It has frequently been said by geologists that discussions regarding the origin of the earth are outside the province of their science. It is difficult to conceive on what grounds this statement rests. How are we to understand the laws which regulate volcanic action, elevation and subsidence, earthquakes, and other kindred phenomena unless we know how the solid earth was formed? Everything must depend on this.

One of the most noteworthy facts brought before students of astronomy and geology is the extraordinary discrepancy in the evidence presented by the two sciences respecting the age of our planet. Geologists are almost unanimously of opinion that at least something like one hundred millions of years must have elapsed since the first appearance of life on our globe. Astronomers would limit the age of the sun himself from beginning to end, to some such period as thirty millions of years. Whatever opinions may be formed regarding the theories which follow, it must be borne in mind that those now received are admittedly incompetent to

explain facts. While the geologist can apparently furnish satisfactory reasons within the limits of his science, his conclusions clash with the requirements of physical astronomy, and *vice versa.*

The nebula theory of Kant and Laplace is, that all the materials out of which the bodies of our solar system were formed were in the beginning of things resolved in their original elements, and filled all the space of the universe in which these bodies now move. This nebulous mass was in an intensely heated gaseous condition. It condensed towards the centre, and in doing so threw off successive rings which on further disruption and condensation assumed the form of planets. The sun himself is now supposed by most astromers to be almost altogether gaseous to the centre (Young.)*

One of the most interesting questions of cosmical physics is how the sun has been radiating heat into space for millions of years without any apparent diminution of the supply. How is this continued outpouring of heat maintained? If we calculate at what rate the temperature of the sun would be annually lowered by the radiation from its surface, we find it to be $2\frac{1}{3}°$ F. per annum, supposing its specific heat to be that of water, and from 5° to 10° F. per annum, if we suppose it to be the same as most of the substances which compose our globe (Young). It would entirely cool off in a few thousands of years after its formation if it had no other source of heat than that shown by its temperature. It has been attempted to explain the source of its maintenance of heat in two ways. The first is known as the meteoric theory and it is—that the heat of the sun is kept up by the impact of meteors upon his surface. It is considered that though the sun may at some past time have received a large supply of heat in this way, the quantity of meteoric matter now falling is totally inadequate to keep up the supply. The second is the contraction theory which appears to be accepted by most astronomers. As the sun's globe cools off it must contract, and the heat generated by this contraction will suffice to make up the entire loss. Knowing the amount of energy which the sun annually radiates in the form of heat, it has been calculated from the mechanical equivalent of the heat thus radiated, by what amount it must contract to make it up. With the present

* The Sun. International Scientific Series.

magnitude of the sun it has been found that the diameter must contract about 220 feet a year to produce all the heat which it radiates. This rate of contraction diminishes as the sun grows smaller, at such a rate that in five millions of years it will be reduced to one half its present volume. At the present rate of radiation the sun will be as dense as the earth in about twelve millions of years. As to the past, it has been calculated that the heat evolved by contraction from an infinite size or by the falling together of all the parts of the sun from an infinite distance would only have been sufficient to last eighteen millions of years at the present rate of radiation. This is the extreme limit of the heat the sun could acquire. Professor Young says if this hypothesis is true, as it probably is in the main, we are inexorably shut up to the conclusion that the total life of the solar system from its birth to its death is included in some such period as thirty millions of years. No reasonable allowances for the fall of meteoric matter based on what we are now able to observe, or for the development of heat by liquefaction, solidification, and chemical combination of dissociated vapours could raise it to sixty millions.

According to Geikie the argument from geological evidence is strongly in favour of an interval of probably not much less than one hundred millions of years since the earliest forms of life appeared upon the earth, and the oldest stratified rocks began to be laid down.

Let us start on the assumption that the space in which the members of the solar system now move was filled with the matter now forming them. First, as to the constitution of this nebula. We may either assume it to have been one element out of which all substances have been in some way evolved, or we may assume it to have been a mixture of various substances which are themselves elements. Since we have absolutely no proof that the substances known to us as elements can be resolved into a single element, we are hardly justified in making the first assumption. Let us then suppose the nebula to have been composed of different elementary substances, which may have been present in various quantities, and that these substances were uniformly distributed throughout it from centre to surface. Second, as to its condition, we may suppose it to have been in a more or less heated condition or at the absolute zero of temperature. We have already seen that on the assumption that it was in a heated condition we cannot account for such

a maintenance of energy as would satisfy geological requirements, let us assume that the whole was at the absolute zero of temperature. We regard this nebula then as having at first a uniform density throughout, a uniform composition throughout, and at the absolute zero of temperature, *i.e.*, with an entire absence of molecular motion. Now its components cannot have been in a gaseous state, since a gas, to exist as such, requires molecular motion, neither can they have been liquid. They must therefore have been in the solid state of matter. Let us now conceive the whole volume condensing, or growing smaller, by gravitation to the centre of gravity of the whole. It is evident that the matter nearest to the centre of gravity would eventually be the matter at the centre of the sun. Now the heat generated by the collision of a falling body varies as the square of the velocity of that body at the point of impact. But the matter nearest to the centre of gravity would have the least distance to fall, and the force of gravity would there be least. Its velocity therefore at point of impact would be least, so that less heat would be generated by the falling together of any given quantity of matter near to the centre, than would be generated by the falling together of an equal quantity situated at a further distance from it. A body therefore formed in this way would be relatively cold at the centre, and the temperature would increase in a definite ratio towards the surface. The heat generated would not wholly be lost by radiation into space part of it would, by conduction, heat the cooler matter nearer to the centre and would perform work.

On this view of its formation we may then conclude, that the sun was never wholly in a gaseous or plastic state, that its centre at first was cool and solid, that its formation was attended by the gradual development of heat, that as heat was generated the more volatile substances became vapours, that on approaching the surface the heat was much more than sufficient to turn all substances into a gaseous state. As the cooler matter in the interior became heated by conduction, the various materials would on arriving at their successive critical temperatures turn to vapour. In dealing with the question of the maintenance of the sun's energy we have to consider the action of two forces, namely, the contraction of the matter in a gaseous state on its surface, and the expansion from excess of heat of the materials nearer the centre. The question of the duration of the sun's energy

is therefore an extremely complicated one. Any given substance would on arriving at its critical temperature turn to vapour, this vapour would exercise an explosive force on the materials between it and the surface. There are between sixty and seventy elements, and the critical temperature of each one differs. The matter about the surface would be upheaved or disturbed an indefinite number of times. This would continually generate an enormous amount of heat. If this is the case it is an almost hopeless task to compute the duration of the sun's energy. It would depend partly on the proportion in which the various elementary substances were present, and partly on the rate of conductivity of the solid materials deep down from the centre and the resistance offered. Until the greatest possible amount of heat had passed by conduction to the centre, and the vapours formed had performed work, we would not be justified in regarding the sun as a body actually cooling. He is continually parting with the energies, and their expenditure maintains the heat. What is known of the physical constitution of the sun's surface would appear to support this view. There would be a continual storing up of energy, the force of which would be dependent on the amount of resistance to be overcome. The sunspots and faculæ with their periodicity might be caused by the gathering up of the internal forces during seasons, followed by outbursts relieving the internal energies. The eruptive or metallic prominences whose spectra show the lines of sodium, magnesium, barium, iron and other metals, occasionally rise to a height of over 200,000 miles above the chromosphere. The velocity of the motions of these prominences sometimes reaches 200 miles a second. This points to the existence of enormous eruptive forces in the sun's interior. We might regard the sunspots, faculæ, and eruptive prominences as analgous to terrestrial volcanoes, the difference between the solar and terrestrial forces being due to the greater intensity of the former, and to the sun's surface being in an intensely heated gaseous condition.

So far we have dealt with the sun himself and have not considered the mode of formation of the planets. As the nebula condensed heat would be generated by friction between the solid particles themselves while falling, and the more volatile substances would become vapourised, the less easily melted parts would be enveloped in a gaseous atmosphere, and the light particles would not fall so quickly as

the heavier ones. This would occasion a decrease of density at the outer parts of the nebula. Now the formation of the planets can be explained in somewhat the same way as before. The sum total of the rotary motion now existing in the planetary system must have been in the nebula, and as the volume contracted by gravitation towards the centre, its velocity of rotation would constantly increase, so that at last the centrifugal force due to rotation would balance the attractive force of gravity.

The orbits of all the larger planets are approximately in the plane of the ecliptic, and a planet may be regarded as having been formed from masses of the nebula thrown off by centrifugal agencies. On assuming a separate existence from the parent nebula, we must consider its development to have been analagous to that of the sun. There would be a continual falling together of the particles composing it to the centre of gravity of the mass. This condensation would be accompanied by the generation of heat through friction between the particles, and a further differentiation of matter would be occasioned. So that the matter composing satellites would be of less density. The forces at work were exactly the same as those in the sun, but different in degree. We may draw then the following conclusions concerning the earth; that it was never wholly in a plastic or a gaseous state, that its centre was relatively cool and solid and that the temperature gradually increased towards the surface; that through loss of heat by radiation into space a solid crust was formed, and that the cooler matter in the interior became gradually heated through conduction, and the more volatile constituents continually assumed a liquid and vapourous condition. Now these vapours would be obliged to find some outlet. The cooled crust at the surface would crack just in the same way that a boiler full of water, subjected to intense heat and without a safety valve, would crack. Now terrestrial volcanoes are built up along lines of fissure in the earth's crust and almost all the active ones are situated on rising areas. Nearly all can be shown to be thrown up along three well-marked lands or great fissures and the branches proceeding from them. They traverse the surface of the globe in sinuous lines with a general north and south direction and the branches often appear to form connections between the great bands. The first and most important of these bands is nearly 10,000 miles in length. It stretches from near the Arctic Circle at Behring's Straits,

to the Antarctic Circle at South Victoria. The volcanoes in Kamschatka, in the Aleutian Islands, in the Kuriles, and in the Islands of Japan are on this band. The second band starts from near the last in the neighbourhood of Behring's Straits, and stretches along the western coast of the American continent. It is about 8000 miles in length. The third forms a ridge running through the Atlantic Ocean, and divides it longitudinally into two basins. This last chain appears to be verging on extinction, as the number of extinct volcanoes is greater than the active ones, and partial submergence has taken place.

With regard to volcanic phenomena, the two great factors which have to be accounted for are the presence of highly heated rock masses within the earth's crust, and the existence of various vapours and gases in a state of most intimate mechanical but not chemical union with them. (See *Judd on Volcanoes*, page 360.) The active phenomena of volcanoes must be referred to the presence of these gases and vapours.

It may be remarked that the theory advanced explains the linear arrangement of volcanoes, the cause of the intense heat, and the presence of vapours and gases in the earth's interior, without assuming it to be other than a rigid mass.

In investigating the changes and movements which the earth's crust has been subjected to throughout geological time, we must consider the action of two forces. Loss of heat through radiation into space is continually going on from the external portions of the globe. This is accompanied by contraction. On the other hand, access of heat by the materials far down in the interior would give rise to an expanding or explosive force. The extent of this force would depend on the amount of volatile materials among the substances in the earth's interior, the rate of conduction of heat to them, and the resistance to be overcome. In early geological times subterranean action, or rather its effects, may have been less because the crust was not so thick, and the resistance to be overcome would have been less. This may account for the enormous times occupied during the deposition of some of the older formations and the greater uniformity observed among their rocks. If the resistance to be overcome was great the forces would accumulate, but they must at some period find an outlet. The phenomena in

connection with elevation and subsidence, and the formation of mountain chains, may, to a great extent, be explained in this manner. Through extended observations of the rocks in different formations and localities, it has been ascertained by geologists that the subterranean forces are in a state of continual flux over the surface of the globe. They make themselves felt in an area, attain a maximum, and then decline. As regards the formation of mountain chains—The first stage appears to be the opening of a number of fissures running along a line near to that at which, in a long subsequent period, the elevation of the mountain masses takes place. The second stage consists in a general sinking of the surface along the line of weakness and the deposition of great quantities of sedimentary materials. The third consists of a series of movements affecting the parts of the earth's crust on either side of the line of weakness. By these movements a series of tangential strains are produced, which result in the violent up-crushing, folding, and crumpling of the sedimentary materials deposited. Fissures again appear on either side of the original line of weakness from which volcanic outbursts take place. Mountain chains may be regarded as cicatrised wounds in the earth's crust. The subterranean energies after probably accumulating for ages, appear to first find an outlet. Enormous quantities of gases, vapours, and molten rocks are brought to the surface. The forces at last become exhausted and subsidence takes place. The original fissures become closed up and covered with sedimentary deposits of immense thickness. The line of weakness becomes stronger than the adjacent portions of the crust. After long ages the accumulated forces again make themselves felt, elevation takes the place of subsidence, new fissures are formed in the weakest places, the lateral forces come into play, and the sediments overlying the original fissure are upheaved. If we admit the existence of this internal energy, we may have these processes repeated an indefinite number of times over any portion of the earth's crust.

In this paper I do not propose to enter more fully into the subject, but hope, at some future time, to have an opportunity of exhaustively reviewing that branch of dynamical geology which treats of it. I think that by means of this force, a more or less complete explanation of the majority of the most interesting problems presented can be given, especially as regards the causes of the movements of portions of the

earth's crust in the carboniferous age, and the origin of earthquakes, earth-tremors, and earth-oscillations.

It must be remembered that the nebula theory of Kant and Laplace was given to the world before the discovery of the mechanical equivalent of heat. The whole question of the maintenance of the sun's energy would seem to depend on whether the original nebula was in a heated condition or not. Now, the conception of Kant was that the entire universe was filled with this nebulous matter, and that all the heavenly bodies have been evolved from it. If space had been altogether filled with this intensely heated nebulous matter, it is difficult to conceive how heat could have been lost by radiation into space. We know that heat is molecular motion, and we know that molecular motion is caused by intercepted mechanical motion. It is hard to see what *a priori* right we have to assume the presence of intense molecular motion in the original nebula without accounting for it. If we suppose infinite space to have contained an infinite number of almost infinitely small particles at equal distances apart, holding potentially, by virtue of their diffusion, all the energies subsequently evolved, we may assume the entire absence of molecular motion. In its absence the particles must have been in the solid condition of matter. Let them aggregate to centres of gravity, those nearest a centre must at point of impact have acquired less velocity than those falling from a further distance, consequently less heat would be generated, and a body formed thus would be constituted as previously indicated. As to the ultimate origin of these things, science can offer no explanation, but points to the existence of an Infinite and Eternal Power.

## ART. III.—*Irrigation and Water Supply in the Australian Colonies.*

By NEWTON E. JENNINGS, M. Inst. C.E., F.R.I.B.A.

[Read April 12, 1888.]

The want of water in many parts of these Colonies for irrigation, as well as for the working of mines, the supply of stock, and domestic purposes is generally acknowledged, it is consequently unnecessary to use any arguments to prove this

The rainfall, so far as the records show, at least in Victoria, is enough to provide a sufficient supply for all purposes if properly distributed; but being intermittent, and the supply from the various creeks, channels and rivers being variable, it cannot be relied on without the aid of some artificial means. Various plans have been proposed, such as the construction of dams or anicuts in rivers or streams to raise the water to channels for distribution ; the supply of these channels by pumping and sinking wells. In the first case, the dams interfere with navigation, and in most natural watercourses the level of water varies so much, that in order to take off water at the driest seasons, the bed of the channel must be so low that the water level in it, for a considerable distance, will be below the level of the country, and a great deal of the water must be lifted, or else what is frequently the best and most profitable land, viz., that near the river, is left without irrigation, and any expenditure on lifting water where it can be avoided diminishes the profits of the cultivator, and thus renders the land less capable of bearing the cost of works necessary to bring it under irrigation, besides also employing labour which could be profitably utilised elsewhere. Water taken off from the natural channels while in flood also contains a very large quantity of silt, and as the rapidity of the flow is retarded in the channels, both because a very rapid flow would injure the banks, and because the inclination of the bed of the canal is reduced as low as possible in order to keep the level of the water above the level of the country as far as possible, the silt is deposited in the channels, thus causing considerable expense for clearing them. There is always also a tendency

for the head sluices to silt up. The cost of raising water by steam power is very great, necessitating a large initial outlay and a constant fixed expenditure for maintenance, which bears a large proportion to the profit of irrigation, and in case of partial failure of the crops, absorbs probably the whole. The use of windmills for pumping no doubt minimises the cost, but there is an element of uncertainty in their use which it is desirable to eliminate as far as possible, and consequently the supply of water should, wherever practicable, be by gravitation. The supply of water from wells occasions great cost in lifting, as a rule, and the supply is small in comparison to the quantity required, and is seldom profitable except for garden crops, or particularly remunerative ones, such as chilies in India.

The direction therefore to which irrigation schemes should turn, is the regulation of the supply of water by storing it before it reaches the rivers and watercourses, thus reducing the risk of floods, and providing against deficiency in times of drought. The distribution of water so stored is a matter for subsequent consideration. In India, the periods of drought are ordinarily about six months. Here, they are usually about the same number of weeks; the proportion of area to storage required here is consequently much less. If storage is provided for the whole of the area under command, the construction of channels for distribution may to a great extent be postponed, as in most cases only a small proportion of the irrigable land is under cultivation; and, although distribution through the natural channels is in most cases wasteful, this waste might at first be disregarded, and the channels could be constructed as more land comes under cultivation and the necessity for economy arises, while the increased area cultivated would enable the necessary funds for the work to be provided. It would very frequently be found also, that the first cost of storing the water, and thus securing a thoroughly satisfactory system of irrigation would be less, and it would very seldom exceed that of constructing weirs or anicuts on rivers of any size. It does not follow that weirs or anicuts are never desirable, but there is little doubt that in most cases storage is preferable, and that endeavours should be made to adopt this system wherever practicable.

The first steps to be taken are, to note the various catchment basins, and to establish rain gauges in suitable places. Considerable care and judgment is requisite in

selecting these situations, and experience in irrigation works is almost indispensable, so that when sites for reservoirs are selected, it may be possible to ascertain correctly the amount of rainfall which will be intercepted by the reservoir. The gauges should be of one pattern, and a uniform system of observation should be adopted in every case. Care should be taken to note the largest rainfall in limited periods, from one hour upwards, as this is of the greatest consequence to enable proper provision to be made for the discharge of the surplus water when the reservoir becomes full, as any deficiency in this respect is the principal source of danger to a reservoir. Notice should likewise be taken of the longest periods of drought and rainfall, and the minimum and maximum rainfall for extended and continuous periods, so that the capacity of the reservoir may be determined—the object being to store sufficient water for any period of drought, together with sufficient to keep up a full supply before or after the drought, during any time that the rainfall alone is insufficient for the requirements.

The next thing to be observed is the determination of the amount of run off corresponding to any particular rainfall in any district. This depends upon the nature of the soil, the slope of the country, the ratio of rainfall to the time in which it falls, whether the land is under cultivation or not, whether it is bare or wooded, and other local peculiarities. Attempts have been made to reduce these to formulæ in particular instances, but so far no one has succeeded in finding any formulæ or constants which would be applicable to different conditions. It is a subject upon which very little is accurately known, and although the gauging of rivers and streams would, to a great extent, solve the question, the ordinary systems of ascertaining the velocity and discharge give results that are by no means reliable. To give one instance, a river was gauged in the ordinary way with floats, and at the same time a series of observations were taken for every 10 ft. in breadth and every 2 ft. in depth, by means of an electric current meter, and the results of the two series of experiments differed by more than 25 per cent. The same sections of the river were used in each case, so that one element of uncertainty was wanting. Probably the latter was about as correct a result as could be obtained for a large river where it was impossible to take the actual quantity of water that had passed in a certain time, and measure it; but there is always some

amount of error in the section of a river taken in a strong current, and with probably a varying level of water. Whether any correct proportion can be arrived at between observations taken in this way, and those taken with floats in the ordinary manner, remains to be seen; but as really reliable results cannot be obtained without a very large number of scientifically conducted experiments, it will probably be a long time before any very great progress is made in the gauging of rivers and streams, and as the cost of observations taken in the way above named is very considerably greater than those taken in the ordinary manner, it is to be feared that this method will not be very generally practised. It would be very desirable if some arrangement could be made by which the various scientific bodies, engineers, and governments would communicate to each other any observations that were made by them, and the results that each deduced from them. Meanwhile the ordinary observations should be made systematically, and by the very best operators obtainable, but even then it will be necessary to be guided a good deal by the opinions of those who from experience are able to estimate approximately the amount of run off in proportion to the rainfall in different districts and under different conditions.

The next thing is to select the sites for reservoirs in connection with the land to be irrigated. For this purpose men of special experience are required, as they must be able to choose sites favourable for the construction of reservoirs, judge approximately whether the rainfall over the catchment area would be sufficient to fill it, whether if filled it would provide for the irrigation of all the land under its command, and to do this they must be able to judge what land would be irrigable from it. The site for a reservoir should be selected to command an area proportioned to its capacity, and the probable length of drought must also be taken into consideration. The depth of the water should be great, so as to reduce the proportion of loss by evaporation. The dam or bund to impound the water should be as short as possible, to save expense. The foundation must be carefully examined to see that it is suitable, and can be made water-tight. Notice must also be taken of what material is available for its construction, so as to determine whether it would be most advantageously constructed of earth or masonry. There must be a satisfactory site for

a weir or overflow, of such a length as would be necessary to carry off the maximum rainfall, and at a suitable level. It is also necessary to see that a suitable channel to carry off the overflow, either exists, or can be constructed. Note must also be made of the land which is likely to be submerged, as in many cases this is an important factor in the practicability of the scheme. It must also be seen how the head works are to be constructed, and what provision can be made for the distribution of the water; and also what facilities, or otherwise, there are for the provision of a complete system of irrigation channels. In addition to all these items, it is necessary to consider whether the quantity of land under command is sufficient to compensate for the construction of the reservoir and channels, and whether the land immediately irrigable would give a return for the cost of the reservoir, and if not, whether the prospects of additional land coming under irrigation are sufficient to compensate for any present deficiency, and the cost of preparing land not previously irrigated for the reception of water must not be lost sight of; and in estimating the probable cost of the work, the accessibility of the site, or otherwise, the means of obtaining the supplies, and method of housing the men employed, must be taken into consideration.

Having determined that on all the foregoing points there is a balance in favour of the scheme, the surveys can be proceeded with. These will commence with contours at every 10 feet in height, so as to make sure whether the anticipations are so far correct as to render it worth while to proceed. This will be a very small expense, and if found satisfactory, the survey would be continued, and intermediate contours to ascertain the exact contents of the reservoir must be taken. For this purpose, contours every 5 feet will ordinarily be sufficient to prove indisputably that the storage capacity is sufficient for the area under command, and that the rainfall will suffice to fill it up to the height proposed for the weir, and to keep up the requisite supply. In case there has not been a fairly accurate survey of the drainage area, it may be necessary to survey this also; but in cases where there is no doubt that the area is more than sufficient, or the rainfall is so heavy as to make certain of a sufficient supply, this may be postponed, unless the site for the weir is restricted in length, in which case it should be done at once, in order to

see that sufficient waterway can be provided for the surplus water.

After dealing with many other important considerations, Mr. Jennings said, with regard to the materials for construction, it will generally be found that if earth is obtainable which is not of too porous a nature, the cost will be less than stone, even if this is available on the spot. The supply of water during construction must also be taken into consideration, as the most satisfactory way of constructing an earthen dam is to water it and roll it in layers of about 6 inches thick, this forms a stronger and more impervious dam than one with only a puddle wall in the centre. It is desirable, if possible, to face the side slope next the water with stone, and consequently it will have to be noted how near the site this can be procured. Stone or brick will be required for the head works, and in most cases for the weir, and the facilities for procuring brick earth must also be investigated, as well as the question of fuel for making bricks. Sometimes a site, which to an unexperienced eye appears most umpromising, turns out particularly desirable; for instance, it may be possible to construct a tunnel which will bring land under command which at first seems inaccessible, or a weir may be constructed by cutting through rock which would be supposed to be too costly, until it is remembered that the stone excavated will be wanted for the head works and for facing the dam. A low spur may run out from a range of hills, and it might appear as if the length of the dam would be excessive, but on investigation it may be found that this spur is just about the height of the dam proposed to be erected. But the discrimination of all these points can only be acquired by practise, united with natural capacity, and no theoretical knowledge will enable a man to select a site.

To sum up, therefore, what is necessary to be done in order to carry out irrigation, and thus raise the value of land many-fold, it would appear desirable that Government should take in hand the storage of water, so as to avoid any jealousies and conflict of interests. The storage should be on high ground, and well up the rivers or streams, as there can be no question as to the right of Government to intercept the rainfall of its own land, and numberless disputes may arise as to the proportion which may be intercepted or taken from a river. All works of this description should be arranged so as to be reproductive

either immediately, or in the near future, and to make them so, either a charge for water should be made according to the quantity used, or the area irrigated, or else a charge on all land under command which could obtain water if the owners or occupiers wished to take it. Whether there should be different rates for pasture and cultivated lands need not just now be discussed. Investigations as to rainfall and discharge of rivers, &c., should be systematically and energetically proceeded with, bearing in mind, that the longer the period during which such observations are made, the more correct will be the results, and they should not therefore be postponed, until any particular work is about to be executed. The country should be examined by thoroughly experienced irrigation engineers, who should select sites which appear appropriate for the construction of reservoirs, and which command land which is, or is likely to come under cultivation. Some preliminary survey of these sites would be desirable, though not essential, as, if irrigation works are required in any particular district, and funds are available, it would be preferable that these should be completely surveyed, and designs and estimates made, and when time permits, or funds are available, preliminary surveys of the rest can be carried out. If experienced men and money are still available, detailed surveys should be made, so that Government may have in their possession complete irrigation schemes for every part of the Colony, and they would be able to proceed at once whenever the necessity arose in any particular district.

Although irrigation only is mentioned in the above remarks, they are intended to apply to the conservation of water wherever required for other purposes, the only modification being as to the command of land. The questions of the distribution of water and construction of the channels for the purpose, and the discussion of the manner in which the revenue should be raised to make the works reproductive, may be left for remark on a future occasion.

ART. IV.—*An Experiment to shew how the Earth is made to Gravitate towards the Sun.*

By T. WAKELIN.

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ART. V.—*The Rabbit Question.*

By H. C. WIGG, M.D. Ed., F.R.C.S. Eng.

[Read March 8, 1888.]

The loss and even desolation caused in many parts of this country by the excessive multiplication of rabbits, and the great reward of £25,000 offered by New South Wales for their extirpation, have induced many efforts to discover a cure for the plague.

Of these the most important has been that of M. Pasteur; but his proposed remedy is so uncertain, and at the same time contains such elements of danger, that I have thought it right, as a matter of urgency, to direct the attention of the Royal Society to the subject.

He has discovered that a certain virulent epidemic disease found in France and parts of the Continent, and called the fowl cholera, can be easily communicated to rabbits, and with fatal effect. The poison of this disease he intends to scatter broadcast throughout the colonies, hoping in this manner to destroy the rabbits everywhere.

It is this scheme, the prospects of its success, and the grave risks attending it, that we have to consider to-night.

His plan is to obtain the microbe, which is the effective cause of the disease, to cultivate it in properly prepared infusions, until he has multiplied each single particle of the poison into hundreds of millions, and then to spread it over the ground or over food prepared for the rabbits. The microbe is a living being, extremely minute, and found in

the blood of diseased animals, and it is supposed that there is a special one for each form of disease. There is much difficulty in saying whether it is vegetable or animal.

It is now nearly forty years since microbes were first noticed by Davaine, but their real importance as factors in disease was not recognised thoroughly until 1877, when the celebrated paper of MM. Pasteur and Joubert was read before the Academy of Sciences.

These gentlemen selected anthrax, a disease affecting men and cattle, called in the first case "malignant pustule," and in the second "splenic fever," and showed that in the blood myriads of these little organisms were found, either as slender waving rods, or minute oval spores, or as curled filaments; and also proved that the poison if it existed in these could be cultivated out of the body to an indefinite extent without losing any of its infectious virulence. The method was this:—A neutralised decoction of yeast in water was strained and heated so that all germs in it were destroyed, and a drop of the diseased blood was then placed in it. After a day or two it was full of the microbic growth, and a single drop let fall into a fresh quantity of yeast water produced a second crop, and so on. Of course the latter cultivations give the microbe free from any foreign matter, and it is from these that its form is best studied. Over fifty successive cultivations of the anthrax microbe have been made, and the last one was as virulent as the first. I spoke of the spores of the microbe. While the active form is very sensitive to degrees of heat (the typhoid microbe being very inactive at low temperatures, and the anthrax microbe inactive at high ones), the spores, the seeds as one might call them, which form when the protoplasm of the active plant is drying up, can endure the greatest heat and cold, and could be swept in dust storms from one end of the colony to another, carrying disease and death for thousands of miles.

This should be borne in mind when we consider the proposal to carry on the experiments "safely" here within walled paddocks. We might as well build a post and rail fence to keep out the cholera, or attempt to enclose small-pox within open wire network. Even an island would not secure safety, for the germs might be blown across, or be carried on a boat, or on the clothes and hair of the experimenters. This is one of the great dangers—once admitted, the disease is practically uncontrollable.

There is another point that I will ask you to bear in your minds, as upon it hinges all the value of the experiments held on sheep that we have received by a recent mail, and which are to prove that they could not be attacked by the disease. I quote the words of M. Valery Radot, M. Pasteur's son-in-law, and his recognised organ:—"Easily inoculable and fatal to the ox, the sheep, the rabbit and the guinea pig, splenic fever is very rare in the dog and pig. These must be inoculated several times before they contract the disease, and even then it is not always possible to produce it." He proceeds to state that fowls never take it, but that if they are artificially chilled they do take it easily—(the logic is not mine)—and it proves exceedingly fatal to them.

Now all this simply shows that under varying circumstances of temperature and of intensity of the contagion, the microbe affects different animals, *including those rarely susceptible, and those supposed to be never susceptible to its influence.*

Now for the Rheims experiments, to which so much importance has been attached. A walled-in vineyard of 19 acres (8 hectares) was greatly infested with rabbits, and when they had multiplied so much that there was not sufficent herbage left to keep them from starvation, the amiable old lady to whom the place belonged had them fed each day with hay and dry clover. After some time, however, even she found that it was too much and called in M. Pasteur, who saturated the food with his cholera-poisoned broth, and in two or three days there where hardly any of them left. That is, that famished rabbits within an enclosure and accustomed to artificial food one day find that food poisoned and die accordingly, a result that might safely have been predicted even by non-scientific people, and that is all. One reason why this experiment was not dangerous and, indeed, probably why it was allowed to be performed at all: it was not done in summer, and still less in the fierce heat and far sweeping dust storms of our plain; it was done in the depth of a French winter and amid falling snow.

Again, he inoculates one or more sheep, and allows others to be in the fields with the poisoned rabbits, and says they cannot take it because they did not become infected then, but this, too, was done in the depth of winter; and all know how much the action of zymotic poisons is affected by season and temperature.

Information has been withheld as to what birds it attacks, and whether we may expect to lose our domestic poultry of every kind. It is, however, pretty certain that we should lose our native insectivorous birds, and with them the only restraint we possess over locusts and grasshoppers, which, no longer unchecked as they are now, might become a plague far worse than the rabbits. But it will naturally be said, if such things happen here, how is it that they do not occur in France? The answer to this question is twofold. In the first place, whenever a new disease falls upon virgin soil adapted to its growth, it extends with singular rapidity and virulence, and that whether the disease be in man, as small-pox, or in the earth as thistles and brambles. After a time, however and often after the most frightful ravages, the disease appears to have consumed either the whole or a very large portion of the special material required for its growth, and then either disappears altogether or is confined within moderate bounds.

A most striking example of this is within the memory of all. In 1874 King Thakombau left Fiji to pay a visit to the Governor of New South Wales at Sydney on the occasion of his cession of his realm to the British Crown.

While there he contracted measles, a disease entirely unknown in Fiji, and unfortunately returning home before he was free from the microbes, these minute particles spread to his immediate attendants and grew and multiplied in them, till at last the disease swept like a storm over the islands and no fewer than 40,000 people out of that small population died from its affects. After four or five months the epidemic ceased in its virulent character, and now measles there is scarcely more severe than in Europe.

In the same way, I am informed that the growth of the briar rose in Tasmania, which at one time threatened such great mischief to that colony, is now far more easily controlled than at first; and that thistles in Victoria, partly, no doubt, through the special legislation, but partly also from the exhaustion of certain ingredients of the soil, are becoming greatly restricted in area. Now in France the plants, the animals, and the diseases have, for thousands of years, been adapting themselves to each other, and, if I might use a rather far-fetched simile, they have established a *modus vivendi.*

Here we have new birds, new animals, a virgin soil and new climate conditions. Who can tell what results will

occur when these are brought into contact with a new choleraic disease? Next, besides the fact that in France the choleraic microbe is on a worn out soil—worn out for its own purposes, I mean—we must remember that the frosts and snows and rains of the long winter there are unfavourable to the extension of the microbe, while in that country of small farms, where every range of trees, every growing field, acts as a filter, the conditions are totally dissimilar to those on our vast sweeps of plain, "growing weather" all through the winter, and dust winds raking the country straight down from the rabbit infected fields to the fertile districts of the coast. Is there, then, any certainty as to what would be the result of the introduction here of this poison? There is no certainty. Microbes of some of the most malignant diseases are sterile in certain countries; thus, although typhus fever is endemic in England and Ireland, we have never had one case in Australia. It seems as if it could not live out here. And the poison of the yellow fever of America dies out rapidly in England. So it may be with the chicken cholera in the colonies, but that is only a remote chance, and—no one knows.

Lastly, is there any reason why we should endanger our flocks, our green crops, the whole prosperity of the country, at a word from M. Pasteur? He is a man who has done brilliant scientific work, especially in the diseases of silkworms, the diseases of wine, and the investigation of zymotic disease, but who has the intensely French passion for pushing great ideas further than they will go.

A few brief references to his last great work, the cure of hydrophobia, will illustrate my meaning, and at the same time give us a salutary caution as to believing too much of what we are vaguely and grandiloquently told about his successes. He attenuates the virus of mad dogs by passing it through the systems of a rabbit and a monkey, and then injects with modified cultures, usually from the monkey's brain, into men and dogs as a protective and curative measure. For a year or two all went on well, and one enthusiastic writer even declared that he had "built (upon mad dogs) the eternal temple of his fame." Centres for mad dog vaccination were established at Vienna, Buda-Pesth, and half a dozen other towns; and in March 1886, we find from the *Lancet* that 350 cases had been treated by M. Pasteur, and that but one death had occurred, and that in a case recognised as very serious from the beginning. On 15th

May we find that three persons more have died from one set alone. On 12th June another is dead; on 21st August a boy is dead; on 28th August three more boys, two French and one English; on 4th September a patient dies; on 13th November another, and so on. Then at the end of December the statistics of the Pasteur Institute for the previous 14 months are published, and we find that 31 of the patients are dead; but it is conclusively proved to us in the report by figures (which cannot lie) that during this period M. Pasteur had saved the lives of 163 of his patients. This was a truly great result, and would have excited much admiration had not Professor Peter, of the Hôpital Necker, pointed out from the vital statistics that the average mortality for the whole of France before the discovery of the infallible cure was 30 per annum. And to obtain this result thousands of men and women, many never bitten by rabid animals at all, have been inoculated with the virus and are scattered all through France.

The poison intended for us is now on the ocean, and scarcely a fortnight's sail from our shores. Two of M. Pasteur's assistants are on board the *Cuzco* with large supplies of the choleraic microbe, and perhaps even the germs of other diseases as well. The opinion I offer to you, and which I hope that you, as the leading scientific body in Victoria, will confirm, is that our Government should immediately take steps to make not only the introduction but the use of these things highly penal. It seems to me that in trifling with such diseases we should be rushing blindly towards a precipice; and what lies in the darkness beyond it no man living can say.

ART. VI.—*An Alphabetical List of the Genera and Species of Sponges described by H. J. Carter, Esq., F.R.S., together with a Number of his More Important References to those of other Authors, with an Introductory Notice.*

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[Read June 14, 1888.]

## I.—INTRODUCTORY NOTICE.

Mr. Carter is, and has for a long time, been justly recognised as the oldest and most experienced of all those who have made a special study of the sub-kingdom *Porifera*, or Sponges.

He produced his first paper on the subject, entitled "Notes on the Species, Structure, and Animality of the Freshwater Sponges in the Tanks of Bombay," whilst stationed at Bombay as a surgeon in the army. This paper was published in the "Transactions of the Bombay Medical and Physical Society" of 1847 (No. 8), and was reprinted in the "Annals and Magazine of Natural History (Series 2, vol. I) in the following year. The last paper on the subject which appeared from his pen, on a collection of sponges from the Mergui Archipelago, was published only last year in the *Journal of the Linnean Society of London*, and in the same year he published four other papers in the "Annals and Magazine of Natural History."

In the forty-one years from 1847 to 1887 (inclusive), Mr. Carter has published no less than 125 papers on sponges, a far greater number than any other author. These papers treat of nearly 800 distinct species of sponges, arranged under over 200 distinct generic names. By far the greater number of these 800 species are described by Mr. Carter for the first time.

Although both his first and last papers were published elsewhere, it was a very rare exception for Mr. Carter to publish anywhere except in the "Annals and Magazine of

Natural History," which renders the study of his papers, and the production of such a list as the present, a far easier task than it would otherwise have been.

It is much to be regretted, however, that Mr. Carter has never been able to collect his numerous observations and bring them together in a more coherent form. As it is, they remain scattered about in a state of almost hopeless confusion through the 125 papers above mentioned, and without the assistance of some such list as the present, it is difficult to gain a correct idea of his work.

The greater portion by far of Mr. Carter's work is purely systematic, and consists in the description of new species; but he has also written on the Anatomy and Embryology of the group. He commenced, as we have seen, in 1847, with the study of the Freshwater Sponges, and in the series of papers which he published on this subject, there are some extremely important observations which have hardly attracted as much attention as they deserve. This might be said of a good many of Mr. Carter's observations, and it is possibly due to the fact that they are mostly more or less buried in a mass of purely systematic description, which none but a specialist would ever think of reading. Mr. Carter is a wonderfully careful and accurate observer, and considering the early date at which his observations on *Spongilla* were made, when the study of sponges was practically virgin soil, his results are most remarkable.

Between the years 1849 and 1868 only two papers appeared in his name, but from 1868 onwards, until the middle of 1887, not a year has passed in which he has not published something about sponges. The year 1874 was marked by special activity, for in this year he commenced the publication of his "Descriptions and Figures of Deep Sea Sponges and their Spicules from the Atlantic Ocean, dredged up on board H.M.S. *Porcupine*,"* and in the same year he published two important papers on the Development of Marine Sponges.† The *Porcupine* reports are decidedly the most valuable of Mr. Carter's systematic papers, and the papers on the Development of Marine Sponges are undoubtedly the most important of his more purely biological works.

The progress of the work on the *Porcupine* sponges was interrupted by the publication, in 1875, of the "Notes

* A. M. N. H. Ser. 4. Vol. xiv, p. 207, *et seq.*
† A. M. N. H. Ser. 4. Vol. xiv, pp. 321, 389.

Introductory to the Study and Classification of the Spongida."* The publication of these notes appears to have been suggested to Mr. Carter by the obvious necessity of having some definite system upon which to arrange his numerous species. The plan of the "Notes" was a comprehensive one. They were to consist of three parts, and were to form a kind of general guide to the whole subject, which was rapidly becoming more and more complex. The three parts were to be—(1) Anatomy and Physiology; (2) Proposed Classification of the Spongida; (3) A further Division into Sub-families, Genera and Species, so far as our knowledge extends.

The first part was a general account of the anatomy and physiology of sponges, including those structures, viz., the skeletal elements, upon which the subsequent classification was based. The second part contains Mr. Carter's scheme of classification, which is sufficiently well known to all spongologists, but which has never obtained general acceptance. He himself, however, has adhered to it systematically, and its appearance at this stage was therefore of great importance to the student of his papers. The promised third part, which should have been a kind of coping stone to the whole structure, most unfortunately never appeared. After the publication of the second part, Mr. Carter returned to his work on the *Porcupine* Sponges, the descriptions of which he completed in 1876.

Between 1876 and 1885 there appeared a long series of miscellaneous papers on sponges, which need not here be specially noticed. In 1885, however, an event took place of special interest to Victorian Naturalists, namely, the appearance of Mr. Carter's first paper† on the splendid series of sponges from the neighbourhood of Port Phillip Heads and Western Port, collected and sent to England by Mr. J. Bracebridge Wilson, M.A. Henceforth, Mr. Carter devoted almost all his energy to working out and describing these sponges, and he published a series of fifteen papers upon them in the Annals and Magazine of Natural History. In these fifteen papers he records 211 species and varieties, nearly all of which were new to science and all collected by Mr. Bracebridge Wilson.

After the conclusion of this laborious work, in 1887, Mr. Carter published two noteworthy papers of a more strictly

* A. M. N. H. Ser. 4. Vol. xvi, pp. 1, 126.
† A. M. N. H. Ser. 5. Vol. xv, p. 107.

biological character—the first "On the Position of the Ampullaceous Sac and the Function of the Water Canal-System in the Spongida;"* and the second, "On the Reproductive Elements of the Spongida."† The latter was his last sponge paper in the Annals and Magazine of Natural History, in which he had now been publishing for 41 years. It was succeeded by his report on the sponges of the Mergui Archipelago, in the *Journal of the Linnean Society of London*,‡ which, however, Mr. Carter informs me was written so far back as 1883.

As Mr. Carter has at length been obliged by the state of his health to cease working at his favourite subject, and as we shall probably have no more papers on sponges from this indefatigable and able naturalist, it has occurred to me that I might perhaps benefit other naturalists as well as myself by the publication of a complete list of all the genera and species which he has described. These are arranged in alphabetical order, with full references to the places where the descriptions are to be found, and it is hoped that the list will serve as an index to Mr. Carter's papers.

The list of genera and species was compiled whilst I was working in the Natural History Department of the British Museum, and it contains 985 references, every one of which was obtained from the original paper. In addition to the species described for the first time by Mr. Carter himself, which are distinguished by the presence of his name attached to them, the list contains a number of his more important references to the species of other authors. Care has been taken to give all the names exactly in the form in which they appear in Mr. Carter's works, and although subsequent research will probably necessitate considerable modification in Mr. Carter's nomenclature, I have felt that it would be out of place to attempt any such modification here.

It may be of especial interest to Victorian Naturalists to observe, that more than a quarter of the species and varieties mentioned in the list are recorded by Mr. Carter from the neighbourhood of Port Phillip Heads and Western Port.

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* A. M. N. H. Ser. 5. Vol. xix, p. 203.

† A. M. N. H. Ser. 5. Vol. xix, p. 350.

‡ *Jour. Linn. Soc.* Vol. xxi, p. 61.

## II.—Alphabetical List.

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|---|---|---|---|
| Acanthella cactiformis | Carter | A.M.N.H. 5, | xv, p. 114 |
| | | A.M.N.H. 5, | xvi, p. 364 |
| ,, hirciniopsis | ,, | A.M.N.H. 5, | xvi, p. 364 |
| ,, stipitata | ,, | A.M.N.H. 5, | vii, p. 380 |
| Acanthellina parviconulata | ,, | A.M.N.H. 5, | xvi, p. 365 |
| ,, rugolineata | ,, | A.M.N.H. 5, | xvi, p. 365 |
| Acarnus innominatus | | A.M.N.H. 4, | vii, p. 273 |
| | | A.M.N.H. 4, | xvi, p. 195 |
| Acervochalina claviformis | Carter | A.M.N.H. 5, | xviii, p. 376 |
| Agelas dispar | | A.M.N.H. 4, | xvi, p. 195 |
| Alcyoncellum corbicula | | A.M.N.H. 4, | xii, p. 367 |
| ,, speciosum | | A.M.N.H. 4, | xii, p. 367 |
| Alcyonium purpureum | | A.M.N.H. 4, | xvi, p. 197 |
| | | A.M.N.H. 5, | ix, p. 352 |
| Alectona Higgini | Carter | A.M.N.H. 5, | vi, p. 58 |
| ,, Millari | ,, | J.R. Micro. Soc., vol. ii, | p. 494 |
| Amorphina anonyma | ,, | A.M.N.H. 5, | xvii, p. 49 |
| ,, cancellosa | ,, | A.M.N.H. 5, | xvii, p. 50 |
| ,, megalorhaphis | ,, | A.M.N.H. 5, | vii, p. 368 |
| ,, nigrocutis | ,, | A.M.N.H. 5, | xvii, p. 50 |
| ,, stellifera | ,, | A.M.N.H. 5, | iii, p. 344 |
| Amorphinopsis excavans | ,, | Jour. Linn. Soc., vol. xxi, | p. 77 |
| Aphrocallistes beatrix | | A.M.N.H. 4, | xii, p. 359 |
| | | A.M.N.H. 4, | xii, p. 451 |
| ,, Bocagei | | A.M.N.H. 4, | xii, p. 359 |
| | | A.M.N.H. 4, | xii, p. 450 |
| | | A.M.N.H. 4, | xvi, p. 199 |
| Aphroceras asconoides | Carter | A.M.N.H. 5, | xviii, p. 134 |
| ,, syconoides | ,, | A.M.N.H. 5, | xviii, p. 135 |
| Aplysina aërophoba | | A.M.N.H. 4, | xvi, p. 191 |
| | | A.M.N.H. 5, | ix, p. 270 |
| ,, cæspitosa | Carter | A.M.N.H. 5, | xviii. p. 282 |
| ,, capensis | ,, | A.M.N.H. 4, | xvi, p. 192 |
| | | A.M.N.H. 5, | viii, p. 110 |
| ,, carnosa | | A.M.N.H. 4, | xvi, p. 191 |
| ,, cauliformis | Carter | A.M.N.H. 5, | ix, p. 270 |
| | P. Acad. Nat. Sci., Philad., | 1884, | p. 202 |
| ,, chalinoides | Carter | A.M.N.H. 4, | xvi, p. 192 |
| ,, compacta | ,, | A.M.N.H. 5, | viii, p. 109 |
| ,, compressa | ,, | A.M.N.H. 5, | ix, p. 270 |
| ,, corneostellata | ,, | A.M.N.H. 4, | x, p. 105 |
| | | A.M.N.H. 4, | xvi, p. 191 |
| ,, cruor | ,, | A.M.N.H. 5, | xviii, p. 286 |
| ,, fenestrata | | A.M.N.H. 5, | ix, p. 272 |
| ,, fusca | Carter | A.M.N.H. 5, | vi, p. 36 |

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| | | A.M.N.H. 5, viii, p. 107 |
| Aplysina incrustans | Carter | A.M.N.H. 4, xviii, p. 231 |
| „ inflata | „ | A.M.N.H. 5, viii, p. 108 |
| „ lævis | „ | A.M.N.H. 5, xv, p. 204 |
| „ longissima | „ | A.M.N.H. 5, ix, p. 271 |
| „ massa | „ | A.M.N.H. 5, xviii, p. 284 |
| „ nævus | „ | A.M.N.H. 4, xviii, p. 229 |
| | | A.M.N.H. 5, xviii, p. 285 |
| „ purpurea | „ | A.M.N.H. 5, vi, p. 36 |
| | | A.M.N.H. 5, viii, p. 103 |
| Arabescula parasitica | „ | A.M.N.H. 4, xii, p. 464 |
| Ascaltis Lamarckii | P. Acad. Nat. Sci., Philad., | 1844, p. 208 |
| Ascetta clathrus | | A.M.N.H. 5, xiv, p. 17 |
| Askonema setubalense | | A.M.N.H. 4, xii, p. 361 |
| | | A.M.N.H. 4, xii, p. 368 |
| Aulodictyon Woodwardii | | A.M.N.H. 4, xii, p. 360 |
| | | A.M.N.H. 4, xii, p. 452 |
| Axinella atropurpurea | Carter | A.M.N.H. 5, xvi, p. 359 |
| „ chalinoides | „ | A.M.N.H. 5, xvi, p. 358 |
| „ „ var. cribrosa | „ | A.M.N.H. 5, xviii, p. 377 |
| „ „ „ glutinosa | „ | A.M.N.H. 5, xvi, p. 359 |
| „ cinnamomea | | A.M.N.H. 4, xvi, p. 196 |
| „ cladoflagellata | Carter | A.M.N.H. 5, xviii, p. 377 |
| „ coccinea | „ | A.M.N.H. 5, xviii, p. 378 |
| „ flabellata | „ | A.M.N.H. 5, xvi, p. 361 |
| „ meloniformis | „ | A.M.N.H. 5, xvi, p. 362 |
| „ pilifera | „ | A.M.N.H. 5, xvi, p. 362 |
| „ polypoides | P. Acad. Nat. Sci., Philad., | 1884, p. 205 |
| „ setacea | Carter | A.M.N.H. 5, xvi, p. 359 |
| „ solida | „ | A.M.N.H. 5, xvi, p. 362 |
| „ stelliderma | „ | A.M.N.H. 5, xvi, p. 360 |
| „ „ var. acerata | „ | A.M.N.H. 5, xvi, p. 360 |
| „ villosa | „ | A.M.N.H. 5, xvi, p. 361 |
| „ virgultosa | „ | Jour. Linn. Soc., vol. xxi, p. 68 |
| „ „ var. massa | „ | Jour. Linn. Soc., vol. xxi, p. 68 |
| Axos anchorata | „ | A.M.M.H. 5, vii, p. 382 |
| | | A.M.N.H. 5, ix, p. 288 |
| „ Cliftonii | | A.M.N.H. 4, xvi, p. 198 |
| „ fibulata | Carter | A.M.N.H. 5, vii, p. 383 |
| | | A.M.N.H. 5, ix, p. 288 |
| „ flabelliformis | „ | A.M.N.H. 5, iii, p. 285 |
| „ spinipoculum | „ | A.M.N.H. 5, iii, p. 286 |
| Azorica Pfeifferæ | „ | A.M.N.H. 4, xii, p. 439 |
| | | A.M.N.H. 4, xii, p. 442 |
| | | A.M.N.H. 4, xviii, p. 466 |
| Battersbya Bucklandi | | A.M.N.H. 4. xvi, p. 199 |

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|---|---|---|---|
| Cacospongia cavernosa | | A.M.N.H. 4, | xvi, p. 193 |
| „ sp. | | Jour. Linn. Soc., vol. | xxi, p. 64 |
| Carmia macilenta | | A.M.N.H. 4, | vii, p. 276 |
| Carteriospongia caliciformis | Carter | A.M.N.H. 5, | xv, p. 221 |
| Caulospongia plicata | | A.M.N.H. 4, | xvi, p. 196 |
| „ verticillaris | | A.M.N.H. 4, | xvi, p. 196 |
| Cavochalina bilamellata | | A.M.N.H. 5, | xvi, p. 287 |
| „ digitata var. arenosa | Carter | A.M.N.H. 5, | ix, p. 281 |
| Cellulophana pileata | | A.M.N.H. 5, | viii, p. 258 |
| Chalina compressa | | A.M.N.H. 5, | x, p. 112 |
| „ digitata var. arenosa | Carter | A.M.N.H. 5, | ix, p. 280 |
| „ inornata | | Midland Naturalist, vol. | 3, p. 194 |
| „ oculata | | A.M.N.H. 4, | xvi, p. 193 |
| | | P. Acad. Nat. Sci., Philad., | 1884, p. 204 |
| „ „ var. fibrosa | Carter | Jour. Linn. Soc., vol. | xxi, p. 66 |
| „ „ „ repens | „ | A.M.N.H. 5, | xviii, p. 375 |
| „ palmata | | A.M.N.H. 5, | x, p. 109 |
| „ polychotoma | | A.M.N.H. 5, | xvi, p. 284 |
| „ „ var. anchorata | Carter | A.M.N.H. 5, | xvi, p. 289 |
| „ „ „ angulata | „ | A.M.N.H. 5, | xvi, p. 285 |
| „ „ „ compressa | „ | A.M.N.H. 5, | xvi, p. 284 |
| „ „ „ moniliformis | „ | A.M.N.H. 5, | xvi, p. 285 |
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| **Xenospongia patelliformis** | | A.M.N.H. 4, xvi, p. 198 |
| | | A.M.N.H. 5, ix, p. 357 |

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EXPLANATION OF ABBREVIATIONS.

A.M.N.H.—Annals and Magazine of Natural History.

J.R. Micro. Soc.—Journal of the Royal Microscopical Society.

Jour. Linn. Soc.—Journal of the Linnean Society of London—Zoology.

P. Acad. Nat. Sci., Philad.—Proceedings of the Academy of Natural Sciences of Philadelphia.

Phil. Trans. Roy. Soc.—Philosophical Transactions of the Royal Society of London.

# ART. VII.—*On Two New Fossil Sponges from Sandhurst*

By T. S. HALL, M.A.

(Communicated by A. DENDY, M. Sc., F.L.S.)

[Read July 12, 1888.]

Both the specimens, figures of which I append, were found at Ironbark, Sandhurst, Victoria, in rock of the Landeilo flag age. The spicules are of a dead black colour, and are preserved in a soft, cream-coloured, slightly micaceous schist.

*Genus.*—Protospongia. *Fam.*—Protospongidæ (Hinde). *Sub-Order.*—Hexactinellidæ.

Hinde defines Protospongia as follows:—"Form of sponge unknown. The portions preserved consist either of detached spicules, or fragments of a delicate spicular framework, formed of a single layer of four-rayed spicules of various dimensions. The larger spicules are arranged so as to form regular squares, which are divided by smaller spicules into smaller squares, and these are again sub-divided, so that the surface of a fairly complete specimen resembles lattice-work."

## PROTOSPONGIA RETICULATA (N. SP., FIGS. 1 AND 2).

*Description.*—The specimen is nearly circular in outline, and probably in its living state had a somewhat spherical form. Its length is about 7 cm. and its width about 6 cm. The spicules are cruciform, the four rays crossing at angles varying from 70° to 90°, the variation from the usual rectangular form of Hexactinellid spicules being probably due to compression. The spicules are of various sizes. The larger ones (the rays of which measure 3·5 mm. in length and ·5 mm. in diameter) are so placed that they enclose squares, and smaller spicules, the rays of which measure 1·5 mm. in length, are placed inside these larger squares so as to divide each into four smaller squares. Numerous smaller cruciform spicules are scattered about in an apparently irregular manner, and it does not appear that the subdivision of the squares is carried as far as in typical

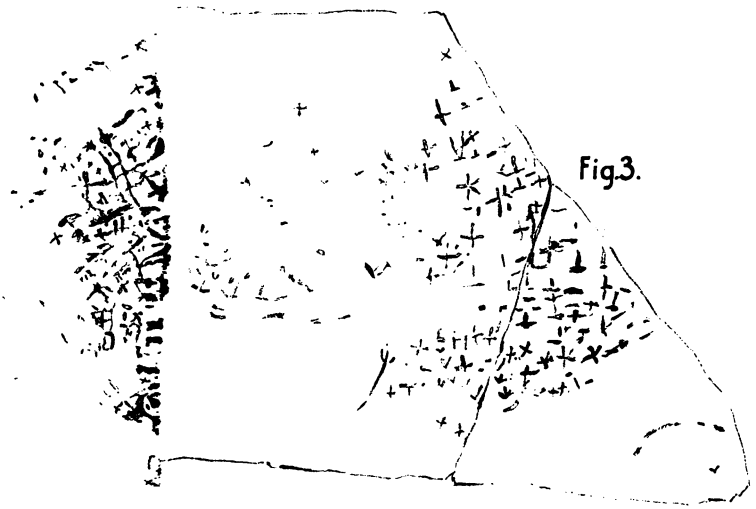
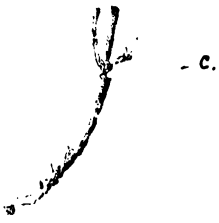


Fig.3.

Fig.4.

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Protospongia. With this exception, the measurements agree very closely with those of a Lower Cambrian form, *P. Hicksi* (Hinde), the figures of which are given in his "British Fossil Sponges," though the description, unfortunately, has not yet appeared.

The specimen was found by Mr. J. E. G. Edwards, of Sandhurst.

### P. Cruciformis (n. sp., Figs. 3 and 4).

Form of sponge unknown. The fragment preserved is somewhat oblong in shape, its width being about 3·5 cm. and its length about 4·5 cm. The spicules are cruciform in shape, the length of the rays being 2 mm. and their diameter ·5 mm. They are placed end to end, so as to form approximate squares. Smaller and irregularly placed cruciform spicules, the rays of which are about ·75 mm. in length, are present in places. In one instance a broken ray, about 1·5 mm. in length, lying in the angle of one of the larger spicules, suggests the possible presence of a fifth ray at right angles to the plane in which the other two lie. At one side of the specimen occurs a spicule about 6 mm. long. This has three rays at one end, forming obtuse angles with it, and may possibly be an anchoring spicule.

The specimen more nearly agrees with Protospongia than with any other form, though the apparent absence of two sizes of squares suggests that it may possibly be of a new genus. A more perfect specimen would, however, be required for the foundation of one.

The specimen was found by Mr. J. O. Liddle, of Sandhurst, and is in the Melbourne University Biological Museum.

My warmest thanks are due to Mr. Dendy for his advice during the preparation of the paper, and for the loan of books on the subject, which I was unable elsewhere to procure.

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## DESCRIPTION OF FIGURES.

### Plate 4.

1. P. reticulata, natural size.
2. Portion of 1 magnified 4 times.
3. P. cruciformis, natural size.
4*a*. 4*b*. 4*c*. Spicules from 3 magnified 4 times.

# Art. VIII.—*Preliminary Notes on the Structure and Development of a Horny Sponge (Stelospongus flabelliformis).*

By Arthur Dendy, M. Sc., F.L.S.

Demonstrator and Assistant Lecturer in Biology in the University of Melbourne.

[Read July 12, 1888.]

## I.—Anatomy and Histology.

(*a*) *External Characters.*—This sponge, which was discovered by Mr. J. Bracebridge Wilson, M.A., near Port Phillip Heads, Victoria, and briefly described by Mr. H. J. Carter in the Annals and Magazine of Natural History, consists of a stout cylindrical stalk terminating below in a basal expansion for attachment to the substratum and above in a broad, compressed, but thick frond. Along the upper margin of the frond is a single row of large oscula. The character of the surface of the frond is subject to considerable variations. On both sides it usually exhibits a number of prominent, branching and anastomosing ridges, enclosing a number of concave depressions. The entire surface of the sponge is more or less thickly encrusted with particles of sand; these are, however, more abundant over the ridges than in the depressions, and the latter are characterised by a minutely reticulate appearance, due to the presence of the inhalant pore-areas. The pores are enormously abundant all over the depressed portions of the surface, but are absent on the ridges.

(*b*) *Skeleton.*—The skeleton is composed of a rather irregular reticulation of cylindrical horny fibres, branching and anastomosing freely. The fibres are rather slender and the meshes between them are wide. It is easy to distinguish primary and secondary fibres. The primaries are long and rather stouter than the secondaries, about 0·096 mm. in diameter. They radiate towards the surface of the sponge, and end in the sandy incrustation. They are easily

distinguished by the presence in them of numerous foreign bodies, which form an axial core, surrounded and held together by the spongin. The secondary fibres are short and contain no foreign bodies, they run in various planes and unite together adjacent primary fibres, meeting them at various angles; they may also branch and anastomose *inter se.*

Thus the skeleton is thoroughly typical in structure and arrangement, and essentially the same as that of the ordinary bath sponge, only much coarser.

In the stalk, the skeleton is more strongly developed, and hence the latter acquires a tougher and denser character than the remainder of the sponge.

(*c*) *Canal System.*—The inhalant apertures, or pores, are thickly scattered all over the depressed areas on the surface of the sponge. These larger areas are themselves subdivided into a great number of smaller ones, which are the true pore-areas, comparable to the pore-sieves of *Phakellia* and *Myxilla.* Each pore-area is irregularly rounded or oval in outline, and measures about 0·19 mm. in its longer diameter. Each one overlies a subdermal cavity, and contains five or six oval or rounded pores, averaging 0·05 mm. in diameter.

The subdermal cavities are hollow spaces in the ectosome, corresponding in size and shape to the pore-areas which they underlie, and communicating with the exterior by means of the pores in the latter. Adjacent subdermal cavities are separated from one another by anastomosing vertical walls of tissue, constituting the bulk of the ectosome, and each communicates below with an inhalant space or canal. Thus each subdermal cavity receives the water from the exterior through five or six distinct apertures (the pores) in its roof, and passes it on through a single (?) aperture in its floor into a large inhalant channel. Just as a number of pores lead into one and the same subdermal cavity, so also a number of subdermal cavities lead into one and the same inhalant channel. There is, however, a good deal of variation in the arrangement of the inhalant canal system, and it would probably be difficult to find two cases in which it was exactly alike. The large inhalant channels, into which the subdermal cavities directly open, lead, in their turn, into an irregular system of much smaller, more or less lacunar channels, whose ultimate ramifications open into the flagellated chambers.

Numerous flagellated chambers open out of one and the same ultimate inhalant lacuna. The chambers themselves are more or less spherical sacs, about 0·04 mm. in diameter, with two wide apertures of about equal size placed at opposite poles, whereby they communicate on the one hand with an ultimate inhalant lacuna, and on the other with an ultimate exhalant lacuna. Several chambers may lead into one and the same ultimate exhalant lacuna.

Both the inhalant and exhalant apertures of the flagellated chambers are usually drawn out into short and relatively wide cameral canaliculi, much as in *Euspongia officinalis*, as figured by Schulze.

The exhalant canal system is partly lacunar and partly composed of very definite tubular canals (the oscular tubes) with proper walls of their own, separable from the remainder of the choanosome. The ultimate exhalant lacunæ, into which the flagellated chambers open, collect together and finally discharge their contents into branches of the oscular tubes. Each oscular tube is a perfectly definite, wide, cylindrical canal, with distinct walls, and leads vertically upwards to a wide circular osculum situated on the upper margin of the sponge.

In connection with the exhalant canal system, I must also mention certain spherical cavities lying in the neighbourhood of the oscular tubes, and containing each a single large embryo. These cavities appear now to be entirely closed and cut off from the remainder of the canal system of the sponge, but it is possible that they are really portions of the exhalant canal system, specially modified to serve as receptacles in which the embryos are lodged during a large portion of their development.

*(d) Histology of the Soft Tissues.*

A. *The Ectosome.*—The ectosome forms an external layer of varying thickness all over the surface of the sponge. Owing to the presence in it of a large amount of sand, especially abundant on the raised ridges, it is very hard and tough, and forms an excellent protection against the attacks of parasitic crustaceans, worms, &c., to which sponges are very subject.

The outermost layer of the ectosome is formed by an extremely thin and delicate epidermis, most readily visible in the pore-areas, where the sand grains are absent. The nuclei of the epidermic cells may be easily distinguished in the transparent pore-bearing membrane; they are round or oval in shape, and about 0·0048 mm. in diameter.

Beneath the epidermis a very large proportion of the ectosome is occupied by the sand grains above mentioned, but surrounding these is a considerable quantity of mesodermal tissue. This is for the most part made up of cystenchyme, but stellate mesoderm cells are also present.

The name *Cystenchyme* has been applied by Sollas to a peculiar form of tissue not uncommonly met with in the ectosome of sponges. In *Stelospongus*, the cystenchyme cells are oval or subglobular in shape, measuring about 0·024 mm. in diameter, and the nucleus is small and granular. The protoplasmic strands which connect the nucleus to the cell wall are best seen in unstained preparations mounted in glycerine. They are then seen to form a network, branching and anastomosing *inter se*. In balsam preparations, owing doubtless to the greater transparency, the protoplasmic strands are not nearly so distinct.

I may mention here that cystenchyme occurs also in the choanosome of *Stelospongus*, but to this point I shall return later on.

The stellate mesoderm cells of the ectosome appear to be thoroughly typical. They may be seen investing the grains of sand in a kind of delicate network, the individual cells being mutually connected by long delicate processes. The body of the cell is somewhat granular, and the nucleus is oval and of moderate size.

(B.) *The Choanosome.*

(1) The walls of the inhalant and exhalant canal system.—It will be convenient to give these the first consideration because of their close relationship to the ectosome, from which they cannot be sharply separated.

The larger or proximal portions of the inhalant canal system are provided with special walls of mesodermal tissue. The true nature of this lining membrane is difficult to determine. In sections it is seen to consist of a very much vacuolated, gelatinous substance, composed more or less of cystenchyme, but in parts becoming fibrous.

The ultimate inhalant lacunæ have no special mesodermal walls, but here the nuclei of a lining epithelium can be easily detected in thin sections.

The ultimate exhalant lacunæ also have no special mesodermal walls, but are lined by a delicate flattened epithelium. The larger exhalant canals, or oscular tubes, are, however, provided with most distinct walls, which can

be dissected out from the underlying tissues with great ease. These walls are membranous and fairly tough, and they are continued from the oscular tube along its various larger branches as a distinct lining membrane.

The wall of the oscular tube is seen in transverse section to be made up of the following layers, from within outwards; (*a*) Furthest from the lumen of the tube, a thick, rather irregular layer of very much vacuolated, gelatinous tissue; (*b*) A much thinner layer of deeply staining, fibrous tissue, in which the fibres are closely packed and arranged circularly around the oscular tube. (*c*) A continuous layer, only about one cell thick, of cystenchyme.

I have no doubt that the wall of the oscular tube is completed on the inside by a delicate, flattened epithelium, but I have not succeeded in demonstrating its presence.

(2) The walls of the embryo-containing cavities.—Whatever view may be adopted as to the relationship of the embryo-containing cavities to the exhalant canal system, it will be convenient to describe the structure of their walls in this place.

The only ovum which I have observed, previous to the commencement of segmentation, lies in a small cavity about 0·1 mm. in diameter, situate in the innermost part of the gelatinous layer of the wall of an oscular tube. This cavity has a special wall composed of fibrous tissue, with elongated nuclei. I have not detected any lining epithelium, although some of the nuclei observable may possibly belong to a delicate epithelial layer.

The large embryo-containing capsules are doubtless developed by growth of the small ovum-containing capsules. The walls of the large capsules are, however, very much more highly developed, and consist of two very distinct layers:—(*a*) A fibrous layer, and (*b*) a lining epithelium. The fibrous layer is very dense next to the lining epithelium, but further in it becomes looser, and is broken into by large lacunar spaces. It is composed of circularly arranged fibres, each consisting of a greatly elongated, fusiform, granular cell, with a deeply-staining, oval nucleus in the centre. The fibres are so densely packed in the outer part of the layer, next to the lining epithelium, that the outlines of the individual cells can no longer be distinguished; but further in the cells lie further apart, and the tissue partakes more of the nature of a compact, stellate mesoderm.

The lining epithelium of the embryo capsule is very peculiar, and, so far as I am aware, entirely different from anything which has hitherto been described in sponges. It is composed of a single layer of enormous polygonal cells. These cells, although flattened, are thick. In the youngest embryo capsule they average about 0·072 mm. in diameter, but up to 0·12 mm. in diameter in older ones, and they are about 0·024 mm. in thickness. The body of the cell is finely granular, and each contains in its centre a very large, flattened, oval nucleus, enclosing a number of deeply staining granules. In transverse sections, the outer surfaces of the cells are very often seen to be indented, and these indentations would appear to correspond in some way to the upper portions of the outer layer of cells of the embryo, which in life are closely connected with the epithelial layer of the embryo capsule. In transverse sections also the body of the cell is seen to be granular throughout, but the granules are very much finer around the nucleus than towards the periphery of the cell. The cell always has a very definite bounding wall on its outer and sometimes also on its inner surface; but frequently its inner surface, which in life is pressed against the fibrous layer of the embryo-capsule, exhibits no such wall. In sections the nucleus sometimes appears solid and sometimes as a hollow vesicle provided with a distinct wall and enclosing a granular substance.

These large epithelial cells very readily become detached from the underlying fibrous layer of the capsule, and sometimes remain adherent to the embryo when the latter is removed from the mother sponge.

Owing to its relationships to and intimate connection with the outer layer of cells of the embryo, and for certain other reasons, I believe this peculiar lining epithelium of the embryo capsule to be nutritive in function.

(3) The walls of the flagellated chambers.—The walls of the flagellated chambers are, of course, composed of collared cells, but these cells exhibit certain very interesting details in structure.

Last year Professor Sollas showed* that in certain sponges the collars of the collared cells (*choanocytes*) are united together at their margins by a continuous membrane, which forms a kind of inner lining to the chamber. I have

* Article Sponges in the Encyclopædia Britannica. Ed. ix.

been able to demonstrate the existence of this connecting membrane, which for the sake of convenience we may term Sollas's membrane, in the flagellated chambers of *Stelospongus.*

The collared cells are arranged at about equal distances all around the chamber, but they are interrupted at the proximal pole by the inhalant aperture, and at the distal pole by the exhalant aperture. They are not all of the same size, but largest around the inhalant aperture, and gradually diminishing towards the exhalant aperture, around which they are smallest. Each cell consists of a cylindrical collum or neck with a large nucleus lying in its slightly expanded base (the body of the cell). The collum projects into the chamber, and gives support to the delicate membranous collar, which is rather longer than the collum, and considerably wider at its summit. Thus the whole cell, including the collar, has somewhat the shape of a dice-box, being narrower in the middle than at the two ends. I have not been able to trace any definite outline to the body of the cell, which is imbedded in a highly granular ground substance, but the nuclei are always very conspicuous. The flagella cannot be detected in my preparations, being entirely shrivelled up, or possibly retracted when the sponge was placed in spirit.

The margins of the collars are all connected together by a continuous delicate membrane (Sollas's membrane), which lies in a plane at right angles to the long axis of the collared cell. This membrane is seen in thin vertical sections as a fine thread running from collar to collar. If, however, the sections be taken in a plane more or less parallel to Sollas's membrane, then the latter frequently appears as an irregular network of delicate transparent strands, shrivelled up and distorted by the action of reagents, but easily recognisable lying within the chamber.

From what has been said of the sizes and arrangement of the collared cells in each chamber, it will be seen that the membrane joining their margins will not run parallel to the wall of the chamber, but will be furthest from it at the proximal or inhalant pole, and nearest to it at the distal or exhalant pole. At the proximal pole, in fact, the membrane is widely separated from the wall of the chamber, while at the distal pole, the two became confluent. Hence the membrane has the form of a cup, whose concavity is turned towards the exhalant aperture of the chamber.

(4) The general mass of mesodermal tissue in which the canals, flagellated chambers and other structures are imbedded.—

The flagellated chambers are pretty closely packed together in the choanosome, and together with the various branches of the canal system, make up the greater part of its bulk. Hence the amount of fundamental or ground tissue in which they are imbedded is not very great. What there is is packed full of minute, highly refringent granules, fairly evenly distributed through it. Imbedded in this granular matrix may be observed, here and there, small nucleated cells of irregularly rounded outline, doubtless the amœboid cells of authors. This ground tissue appears to agree thoroughly with that which Schulze has described as existing in Euspongia.

(5) The spongoblasts and other mesodermal cells surrounding the fibres.—

In most parts the skeleton fibres are surrounded by a sheath of ordinary stellate or slightly fibrous connective tissue. In some places, however, the stellate mesoderm cells are specially modified as *spongoblasts* or glandular cells whose function it is to secrete the spongin of which the horny fibre is composed. The spongoblasts form a layer one cell thick around the fibre. Each one is a somewhat club-shaped, slender, elongated, granular mesodermal cell, about 0·048 mm. long; one end is drawn out into a long, gradually tapering neck, and the other, broader end is usually rounded off, but sometimes stellate, and contains a spherical nucleus. The whole cell is frequently more or less bent or contorted. Its long axis, however, always lies approximately at right angles to the surface of the fibre against which its narrow end abuts. There is commonly, if not always, a layer of stellate mesoderm outside the layer of spongoblasts, and it is easy to see that the spongoblasts themselves are simply slight modifications of the ordinary stellate type of cell.

## II.—Development.

My observations on the embryology of *Stelospongus* are as yet very imperfect, for all the embryos which I have as yet found are in pretty much the same stage of development. Of this particular stage there is, however, an abundant supply, and it presents some very remarkable features.

The ovum, of which I have found one example in my sections, appears in section as a somewhat oval cell, lying in a fibrous capsule, as described above. The body of the ovum is granular and deeply staining. At one pole there is a large, oval nucleus, with a very definite wall, and right up against the wall at the outer pole of the nucleus there lies a small, spherical nucleolus. Within the nucleus there is a quantity of coarsely granular protoplasm, chiefly aggregated towards the pole remote from the nucleolus. The nucleolus stains deeply and is almost if not quite homogeneous.

The embryos, which are abundant, are spherical solid bodies, about as large as small peas. When the surface of the embryo is examined with a pocket lens, it exhibits a minutely punctate appearance, due to the presence of an immense number of shallow pits, somewhat polygonal in outline and separated from one another by low ridges. Each one of these pits is the imprint of one of the large epithelial cells of the embryo capsule.

In sections, the embryo is seen to consist of an outer layer of rather large, closely packed cells, enclosing a central mass of clear, transparent, jelly-like substance, in which immense numbers of amœboid wandering cells are imbedded. The outer layer, or ectoderm, consists of a single layer of large, sac-shaped or somewhat flask-shaped cells, measuring about 0·024 mm. in length. The narrower portion, or neck of the cell is on the outside of the embryo, and the swollen portion projects inwards into the gelatinous intercellular substance, and from its inner extremity the cell frequently sends out a few short, slender, protoplasmic processes, resembling pseudopodia. The body of the cell is coarsely granular, but less so in the neck than in the swollen portion. The greater part of the neck is, however, occupied by a large, spherical nucleus, which appears to consist of a hollow vesicle containing a few deeply staining granules. The nuclei of adjacent cells are all arranged at just about the same level, so that they form a continuous row, which is a very conspicuous feature in transverse sections of the embryo.

Frequently the outer end of the neck of each ectodermal cell may be seen to be drawn out into a short, slender protoplasmic process, which extends to the outer surface of one of the large, investing epithelial cells and attaches itself to it. Thus the ectodermal cells of the embryo often appear to be suspended from the outer surfaces of the investing epithelial cells by short protoplasmic processes. Judging

from the number seen in a single transverse section, it would appear that each of the large epithelial cells may have a hundred or more sac-shaped ectodermal embryonic cells hanging from its lower surface.

The unusual length of time during which the embryo remains within the mother sponge, and the great size to which it attains, necessitate some special arrangement whereby it can be nourished. The peculiar relations of the ectodermal cells of the embryo to the investing epithelium, and the very unusual character of the latter, cause me to believe that the investing epithelium has for its function the nutrition of the embryo, and that this is effected by the absorption of nutriment through the necks of the ectodermal cells.

Sometimes, however, the ectodermal cells exhibit no prolongations of the neck, but are smoothly rounded off at the free end, and such cells may form a continuous layer over a considerable area.

The entire mass of the embryo, within the ectodermal layer, is made up of a clear, jelly-like matrix, in which immense numbers of large, amœboid wandering cells are imbedded. These cells appear somewhat larger than the ectodermal cells, but there is very strong reason for believing that they are simply ectodermal cells which have left their place in the outer layer and, becoming amœboid, wandered into the central jelly. Between the large amœboid cells very delicate branching stellate cells may sometimes be seen. The amœboid cells may put out pseudopodia in all directions, but often they appear to be radially elongated, and more or less bi-polar. I think my sections show conclusively that the amœboid cells are derived from the ectodermal layer. They agree at first in all essentials with the cells of the latter, and in those parts where the ectodermal cells have the clearer, outer end of the neck evenly rounded off—and thus present a characteristic feature—a precisely similar clear rounded neck may often be seen in the cells immediately beneath the ectoderm.

The amœboid cells are from the first highly granular, and at what I believe to be an early stage in the proceedings each one has a spherical nucleus, resembling that which occurs in the ectodermal cells. Sometimes the amœboid cells lying near the outside of the embryo have two or three nuclei, and very rarely also even the ectodermal cells appear to have two nuclei. At a later stage, the entire cell is seen to

have become indistinct in outline, and in place of one large cell we have an aggregation of very many minute spherical bodies, each with a dark spot in its centre, but each aggregation still retains the form of the original amœboid cell. In the same sections which exhibit this condition many of the amœboid cells appear to have become rounded off, and their contents have arranged themselves around a central cavity, so that we have a hollow chamber lined by small spherical cells. These chambers I believe to be the young flagellated chambers. They are certainly very different in structure from the flagellated chambers of the adult sponge, and only about half the size; but this difference is readily explained by their embryonic condition. I have not been able to trace the development of the chambers any further, nor is it to be expected that the collars and flagella would be developed before the young sponge was set free and required them.

Coincidently with the formation of the chambers in the manner just described, a slit-like invagination appears on the surface of the young sponge, and it is chiefly, if not solely, around this invagination that chamber formation takes place. This invagination I believe to be the commencement of a communication between the chambers and the outside. Unfortunately, I have only obtained a single embryo which is sufficiently advanced to show the formation of the flagellated chambers and the slit-like invagination, but I see no good reason for doubting the normality of the phenomena above described.

It thus appears that the flagellated chambers in *Stelospongus* are formed by the breaking up of large amœboid cells, exactly as described by Mr. Carter in the development of the gemmules of *Spongilla*.

## Art. IX.—*The Active Volcano on Tana, New Hebrides, with some remarks on the Cause of Volcanic Action.*

With Map and Plates 5, 6, 7 and 8.

By Frederick A. Campbell, C.E. (Melb.)

[Read 11th October, 1888.]

Tana is one of the southern islands of the New Hebrides group, and lies approximately in 20° south latitude and 170° east longitude. It is about 30 miles long by 12 miles wide, and is densely covered with the most luxuriant tropical vegetation. The interior is occupied by a range of mountains which rises to a height of about 2500 feet, and so far as I know, has never yet been explored. The shores are partly fringed by a narrow coral reef, outside of which the water deepens rapidly, and good anchorage is difficult to find. There is only, or more correctly speaking was only until recently, one harbour on the island, viz., Port Resolution, a picturesque basin about one mile in diameter, situated upon the south-eastern side and opening towards the north.

Four-and-a-half miles to the north-west of this harbour, the active volcano Mount Yasur, is situated. It rises from a plain or wide flat valley which separates the elevated land of the Port Resolution district from the still more lofty ranges of the interior. A ridge 400 or 500 feet high extends from the harbour towards the volcanic cone, descending as it approaches that hill, the summit of which stands about 500 feet above the plain beyond and 700 feet above the sea level.

The volcanic district, that is the area over which are scattered traces of volcanic action, past and present, is about 20 square miles in extent, being a belt about $2\frac{1}{2}$ miles wide, extending from the sea coast outside and to the south of Port Resolution, for a distance of seven miles to the active cone of Mount Yasur.

Plate 5 gives a vertical section drawn through this part of the island. Plate 6 gives a plan of this district upon which I have marked the approximate position of the various volcanic phenomena.

Commencing at the most southerly, these may be briefly catalogued as follows :—

Hot springs on the outer sea coast.

A deposit of contorted ropy lava on the same coast about one mile farther north.

Hot springs on the south-east side of Port Resolution, temperature about 100°.

Hot springs on the west side of Port Resolution, temperature about 200°.

Stratified beds of a sort of argillaceous sandstone, closely allied to pumice stone, and used by sailors for holystoning the decks, alternated with this, bands of cinders or slag. These are seen in the cliffs on each side of the entrance to the harbour, where the sea has exposed a vertical section to view.

Hot beds of white clay occur further to the west. These are soft, when opened with a stick emit jets of sulphurous steam, and have a temperature ranging up to 200° Fah.

A small lake exists to the southward of this, the water of which has a temperature of about 100° Fah.

Beds of sulphur lie close to the active cone, as well as a large deposit of lava which stands piled up to a height of about 200 feet, the precipitous face of which indicates that it has issued forth in a very viscous state.

Just at the foot of the mount and beyond it, there lies a beautiful fresh water lake about one-and-a-half miles long by half-a-mile in width. It is fed by one of the largest streams in the island, it has no outlet to the sea, but disposes of its superfluous waters by pouring them continuously into large crevices on that edge which is next to the volcanic cone.

The cone itself is composed of loose scoriæ lying at an angle of about 2 to 1, with hardened lava protruding here and there, and blocks of a more porous nature strewn upon its surface.

The top of the cone is occupied by two distinct craters of about equal size and form, one, the farthest west being active, the other extinct. The active crater is an oval basin about 700 feet long, 500 feet wide, and 150 feet deep. Two large and one smaller vents occupy the bottom, the larger ones being about 50 feet in diameter; from these and from cracks in the sides of the crater, jets of steam continually rise, and the ground everywhere is almost too hot to touch. Between the eruptions, the crater is empty of lava, and there is nothing but the hissing steam jets to indicate the existence of the tremendous forces imprisoned below.

Plate 7 gives a general view of the volcano from the north-east, the entrance to Port Resolution being shown on the extreme left.

There are two other active volcanoes on this group, and another in the Santa Cruz Islands immediately to the north, particulars of which I have given in a paper recently read before the "Royal Geographical Society of Australasia," and entitled "Some Coral and Volcanic Islands of the Western Pacific."

Whilst Mount Yasur resembles these, in that it is subject to eruptions at times on a very large scale, it differs very materially from them in that, while they rise to about 3000 feet above sea level, it has an elevation of only about 700 feet, while their normal state is that of a steady emission of smoke without noise, that of Yasur is one of rapid and regular, but comparatively feeble, explosions.

## The Eruptions of Mount Yasur.

In the paper previously referred to, I have given the fullest details obtainable from various sources upon this part of the subject; it will be necessary, however, to recapitulate the leading points, and for the sake of presenting the history of this volcano in the clearest form, I have arranged the various records in chronological order:—

1774.—Cook and Forster.—This is the first record of the volcano. They remark that it threw up prodigious quantities of fire and smoke; that the explosions resembled claps of thunder, followed by a rumbling noise, and that showers of rain appeared to increase its violence. Hot springs and solfatarras were observed by them on the west side of the harbour, and it was noticed that when the eruptions were violent, the quantity of steam emitted from these springs was considerably increased. The interval between the eruptions was observed to be about five minutes.

1793.—Labillardière observed it from a distance, and remarks that columns of smoke rose to a prodigious height, and after traversing a great space, sunk as they grew cooler.

1840.—Aneityum Native.—A very violent eruption occurred about this year.

1862.—Turner records the intervals between the eruptions as from six to eight minutes.

1865.—Brenchly notes the intervals as about the same as Turner, and observes that the eruptions were more violent than usual during the months of January, February and March.

1872.—Campbell.—When visiting the group at that time, I noted the period between eruptions as varying from four to six minutes, according to the state of the weather. In the winter, when the trade winds were blowing and the weather was fine, there would be hardly a minute of difference in the intervals for weeks together. So far as I recollect, there was no perceptible difference in the intervals during the day as compared with those during the night, that is, the temperature did not seem to affect the eruptions.

1873.—Markham notes the eruptions as occurring every three minutes.

10th January, 1878 Neilson.—A tremendous eruption took place, accompanied by an earthquake and an upheaval of the land. A fortnight afterwards, this was repeated on a smaller scale.

April 1888. Watt.—A violent eruption took place, accompanied by an earthquake, and further upheaval.

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The eruptions of this volcano may be conveniently divided into three different classes :—1st., The normal or quiescent ; 2nd., the violent ; 3rd., the paroxysmal. I will treat of these in the order named :—

### 1st.—The Normal or Quiescent State.

The interval between the eruptions is on the average from four to five minutes. When particularly sluggish, the interval increases to as much as eight minutes. A longer time than this without eruptions has never been noticed, according to the Rev. Thos. Neilson, who was resident for 14 years at Port Resolution, and therefore is a competent authority on the subject.

The sound accompanying each eruption is a loud report, followed by a more continuous rumbling, almost exactly like that produced by the firing of a heavy piece of ordnance, and this is heard to a distance of about 30 miles. A sensible vibration of the sound is felt at Port Resolution with each explosion. The material ejected from the crater consists of red hot lava in the form of spherical bombs, large irregular fragments, in some cases as large as a horse, clouds of fine volcanic dust appearing as densely black smoke, and steam. The heavy fragments are thrown to a height of 500

or 600 feet above the crater, falling back into it again, or carried by the wind over the leeward edge. The clouds of steam and smoke generally assume a globular form, and carried away by the wind, distribute upon the space over which they pass quantities of fine volcanic dust.

Accompanied by Mr. Neilson, I visited the crater, and spent some time in watching the phenomena of its eruptions. It was difficult, however, under the circumstances to make calm and reliable observations. The noise was so appalling and the situation so unusual and exciting that one could well be pardoned for not collecting much accurate and reliable data. The eruptions were too close also to be studied properly, and the general impression received was of a simultaneous explosion, earth tremor, and projection high into the air of a torrent of stones, lava and smoke. Between these principal explosions however, molten lava occasionally surged up in the vents, accompanied by small explosions and the ejection of fragments to a short distance around, very much as is described as occurring at Stromboli in the Mediterranean. The different vents appeared also to exhibit a certain variety in their action, one of them throwing the lava higher and with a loud explosion, the other throwing up the larger masses with a less degree of force, as if they tapped the reservoirs beneath at points of different pressure.

### 2ND.—THE VIOLENT STATE.

At certain periods the volcano becomes more than usually active, the eruptions being not only more frequent, but more forcible. A greater quantity of material is ejected, and it is thrown to a greater height, much of it falling outside the crater, and rolling down the sides. Referring to this state Mr. Neilson writes:—"Its period diminishes sometimes to 45 or 50 seconds, and during rainy and thundry-looking weather, it will thud away for a fortnight or three weeks at this rate, shaking the whole island at every explosion and being heard to a distance of 50 or 60 miles away.

Mr. Forster, the companion of Captain Cook, more than a century ago, noticed that rainy weather increased the violence of the eruptions, and so did Mr. Brenchly in 1865. I observed that the rapidity and violence was increased not only when the weather grew sultry, and bad weather approached, but also during rain and for a short time after rain.

### 3RD.—THE PAROXYSMAL STATE.

At irregular intervals of time, this volcano and district have been the scene of eruptions upon a scale of unusual violence. Traces of vast disturbances in the past are evident, and in historic times, there are records of three such occurrences, regarding which I have been able to collect the following particulars:—

1840 (Approximately).—Upon the authority of a native of Aneityum, a tremendous eruption took place on Tana about this time, and quantities of pumice stone floated across from Tana to Aneityum.

January 10th, 1878.—Very full details of this eruption have been furnished to me by Mr. Neilson, who was living then at Port Resolution. During the night of the 9th of January the wind had been blowing hard, and the morning broke very dark and lowering. About 9 o'clock a.m. the most severe shock of earthquake known since the islands were settled took place, lasting some four or five seconds. Simultaneously with this, the western side of Port Resolution was raised with an even tilting motion, and a large mass from the face of the cliffs near the entrance was hurled forward into the sea, causing a tremendous disturbance, and projecting a wave some 40 feet high against the land on the opposite side.

The eastern side of the harbour escaped almost entirely, only a few rocks being displaced, but the western side was raised to the extent of about 25 feet. The whole of the district between the harbour and the volcano was shaken and rent by fissures which occurred almost every 100 yards. Several natives fell into these, but were able to extricate themselves before being engulphed. For several weeks afterwards, this district emitted dense volumes of steam from these fissures, and the active cone of "Yasur" presented the appearance of having been partly shaken down, a flow of ashes having taken place westward and into the lake, partially encroaching upon it.

About a fortnight afterwards, another earthquake and eruption took place, with a second upheaval of the western side of Port Resolution to a height of seven feet more.

The volcano itself after about three weeks' display of tremendous eruptive force, gradually resumed its normal state of activity.

Two facts recorded by Mr. Neilson in connection with this outbreak are worthy of notice. 1st. The earthquake which accompanied the first great eruption on the 10th, and was felt so severely at Port Resolution, was not felt at all 12 miles away. 2nd. That on the same day as the eruption on Tana, a violent hurricane was raging at Efate 100 miles to the north, which island is on the direct line which passes through the various foci of volcanic activity in the group.

April 1888.—Intelligence arrived recently of another outbreak of volcanic force on Tana, during April of the present year. Full particulars are not yet to hand, but it appears that the eruption was again accompanied by an earthquake and further upheaval of the western shore of Port Resolution, which fine harbour is now reported to be destroyed, nothing larger than a boat being able to gain admittance.

So far as could be observed from the sea, no great change had occurred in the appearance of the volcano itself, which in June had again resumed its normal quiescent state.

Somewhere about the same time, the volcano on Ambrim also burst forth with great violence, and a great hurricane was raging in the north of the group; whether these three events were synchronous or not, I cannot say.

Having now placed before you all the particulars regarding this volcano available at the present time, I wish to draw your attention to certain conclusions which may, I think, be naturally based upon the facts already recorded. These conclusions refer to the position of the present focus of activity, the depth at which the explosions causing the eruptions take place, and the connection between the phase of eruption and the state of the weather.

On examining the plan of the district, it will be seen that the present focus of activity is at the extremity of the area affected by volcanic heat and pressure, the whole region between it and the sea appears to have been raised at a comparatively recent date, and has no connection with the main island, which is of a different geological formation. It would also appear probable, from the nature of the deposits, that either Port Resolution itself has been at one time an immense crater, or that there has been one about its entrance, The bed of twisted lava on the eastern outside coast-line would appear to strengthen this idea, as it is difficult to believe that it could have flowed from the present position of the volcano, with Port Resolution intervening in a direct line between.

It may I think also be concluded, from a comparison of the two beds of lava, the one referred to and the other close to the present cone, that the internal heat at Tana is diminishing. It may reasonably be assumed that the lava flow near Mount Yasur is the most recent, and this from the way in which it stands piled up presents the appearance of having issued forth in a much more viscous state than that on the outer coast-line.

With regard to the depth below the surface at which the force causing the eruption is generated, two circumstances will assist in determining this approximately. The first is the accompanying earthquake, the second the area of surface upheaved in the violent shocks. Every eruption is attended by an earthquake, which varies in force precisely as the eruption varies in magnitude, and they occur always at the same instant; these earthquakes are confined to the volcanic district, the most severe ever felt, that of 1878, not being noticeable 12 miles away. The origin, therefore, could not have been deep-seated, it being very evident that the deeper the origin, the more widespread and uniform would be the result. In the absence of accurate data as to the direction, the angle of emergence, and the relative force at different distances from the centre, no precise estimate can be made. The depth of the focus of an earthquake which shook the whole of Italy was fixed by Mr. Mallet as being about six or seven miles. The origin of the Tana earthquakes and eruptions must therefore be very much less than this. The fact also of the area upheaved or bulged upwards during the eruptions of 1878 and afterwards, being so small, would appear to strengthen the view that the origin of the disturbance is not deep-seated, for it is quite impossible to conceive of a small portion a few hundred yards in extent being lifted, the land around remaining *in situ*, without bringing the generating force very close indeed.

The connection of volcanic eruptions with the atmospheric pressure has frequently, and especially in late years, received attention, without however establishing it as a matter of fact. This no doubt is due to the incompleteness of the observations, and to the fact that only in connection with such volcanoes as Stromboli, and that on Tana, where the eruptions are so frequent, is it possible to take a sufficient number of observations to be of any value in this matter.

Professor Judd, the latest writer on this subject, referring to Stromboli, says :—" Whether the popular idea, that

the outbursts of Stromboli are regulated by atmospheric conditions has any foundation, is still open to grave doubt. It seems to be certain, however, that during the autumn and winter the more violent paroxysms of the volcano occur, and that in summer the action which takes place is far more equable and regular." This means, I take it, that during that portion of the year exposed to the greatest fluctuations of atmospheric pressure, the volcano exhibits the greatest variety in the phases of its eruptions.

That the Tana volcano is affected in this way, is open to very little doubt at all.

Almost every visitor from Captain Cook onward has noticed and recorded this fact. I had personally the opportunity of observing the eruptions during all kinds of weather, and the increase in their rapidity and force was invariable when the weather became unsettled, stormy weather approached, on the fall of rain and for a short time after rain. The most violent eruptions have always occurred during the summer, that is the hurricane months; in the winter when the trade winds are blowing, and day after day the weather does not vary, the eruptions are very regular and comparatively feeble. Mr. Neilson after an experience of its habits for 14 years reports in the same terms.

Although a series of accurate observations of the eruptions taken in connection with those of a barometer would be of great value in throwing light on this subject, the general law of the connection of the condition of the atmosphere and the nature of the eruptions may be considered as established, so far as this volcano is concerned.

It would be impossible to study the working of this remarkable engine of nature for any length of time without being led to consider the cause of it all, the reason of its regularity and of its irregularities, and the various peculiarities attending it. The inquiry is full of interest but beset with difficulties, so that theories must be advanced and received with caution in the limited state of our present knowledge.

I will, however, conclude this paper with an attempt to account for the varied and remarkable performances of the volcano under discussion.

The generally accepted theory of volcanic action is that it is due to three causes :—1st. The existence of molten lava beneath the surface of the earth's crust; 2nd. The percolation

of water upon these heated layers; 3rd. The escape through fissures or vents of high pressure steam, caused by the contact of the water with the molten lava.

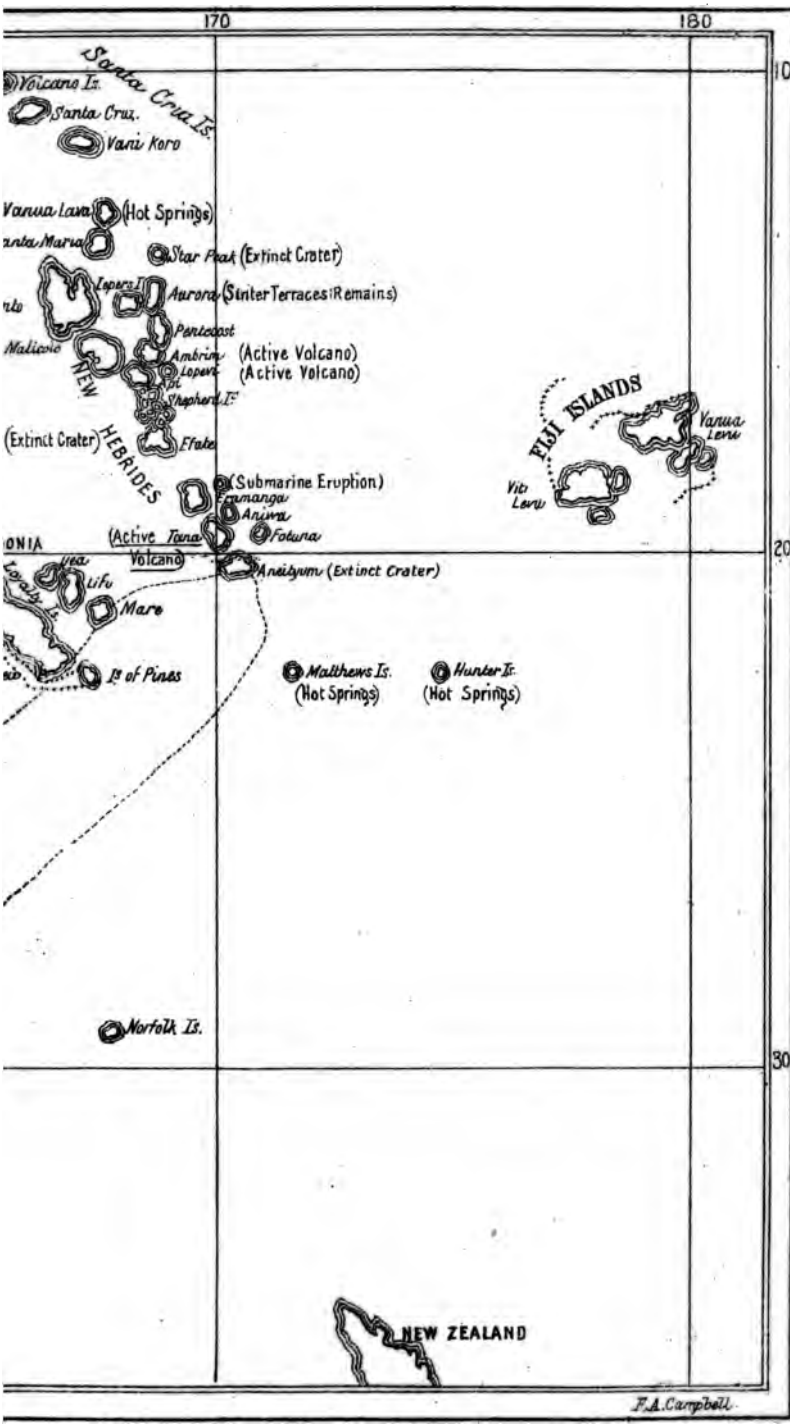
Professor Judd considers that the immediate cause of eruptions is due to the escape of high pressure steam through the lava, in the form of bubbles which rise and burst at or near the surface, much as would be the case if porridge were to be boiled in a tube. Now this does not appear to satisfy the conditions required for explaining the various phases of the eruptions of Mount Yasur, particularly the normal quiescent regular state.

With the aid of a diagram (plate 8), let me suggest another method, or it might be called a modification of the above.

I look upon the Tana volcano as a lava geyser or a natural underground steam machine, depending for its peculiarities upon the nature of the arrangements of the water supply, steam chamber, and outlet vent. I assume a lake of molten lava (F), which at normal atmospheric pressure maintains in the vent (C) a column at about a constant level. (D) is a space above the lava, filled with steam. The vent is tapped at a point below that at which the lava stands by a cave or fissure (B), into which the water supply from the lake (A) finds its way. This water coming into contact with the heated lava is turned into steam, which on the pressure becoming sufficiently strong to overcome the resistance, is forced under the column in the vent and ejects it with great violence. On the escape of the steam, the lava rises again immediately to its former level in the vent, and the steam making process goes on as before. The heat, the atmospheric pressure, and the water supply being constant, there is no reason why this process should not go on for ever with the most perfect regularity.

I may state that I have tested this arrangement practically, and have succeeded in obtaining the result as stated above, *i.e.*, a perfectly regular spasmodic ejection of fluid from a pipe by the steady admission of steam at a point below its surface.

As the molten lava would also contain steam at considerable pressure, or water ready to turn to steam, absorbed from the ocean, the effect of the escape up the vent of a considerable volume of free steam, and the emptying of what I have called the steam chamber, would be to cause a sudden decrease of pressure and an additional quantity of steam to be formed which would aid in the ejection of the lava.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Santa Cruz Is.
Volcano Is.
Santa Cruz.
Vani Koro
Vanua Lava
(Hot Springs)
Santa Maria
Star Peak (Extinct Crater)
Aurora (Sinter Terraces & Remains)
Pentecost
Malicolo
Ambrim (Active Volcano)
Lopevi (Active Volcano)
Shepherd Is.
NEW HEBRIDES
(Extinct Crater)
Efate
(Submarine Eruption)
Erromanga
Aniwa
(Active Tana Volcano)
Fotuna
Aneityum (Extinct Crater)
Lifu
Mare
Is. of Pines
Matthews Is. (Hot Springs)
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Vanua Levu
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Norfolk Is.
NEW ZEALAND
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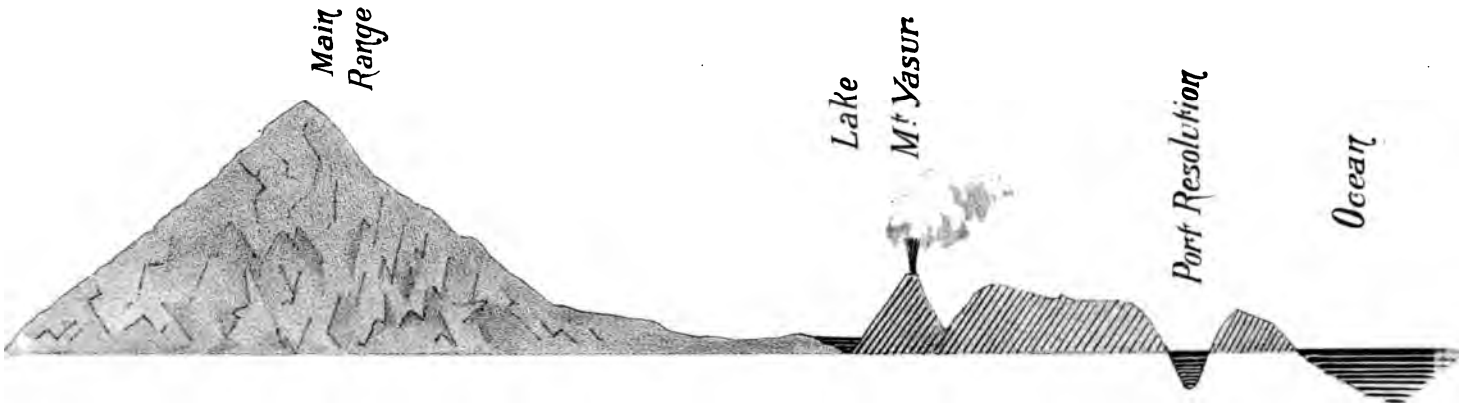


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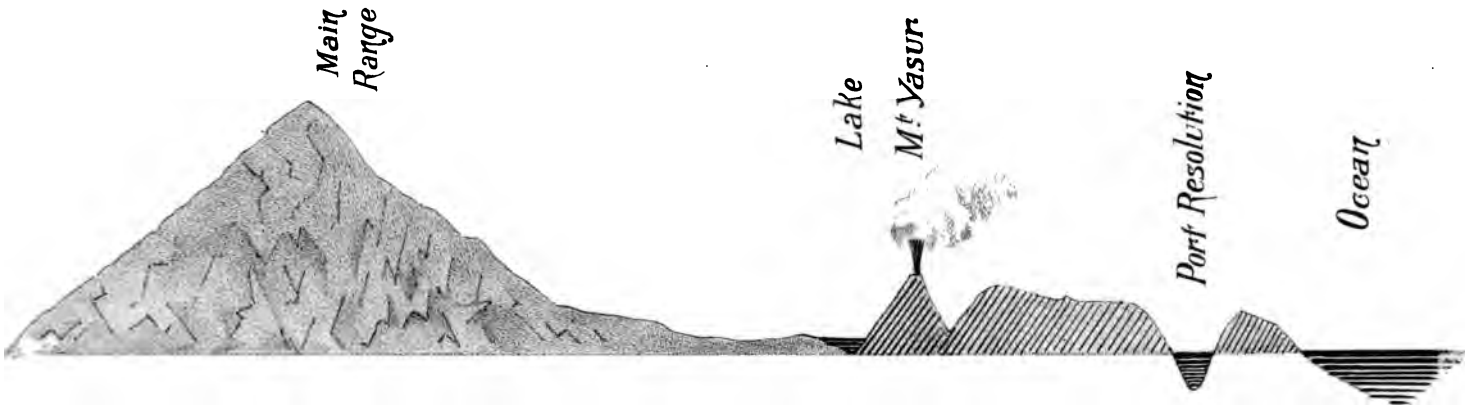


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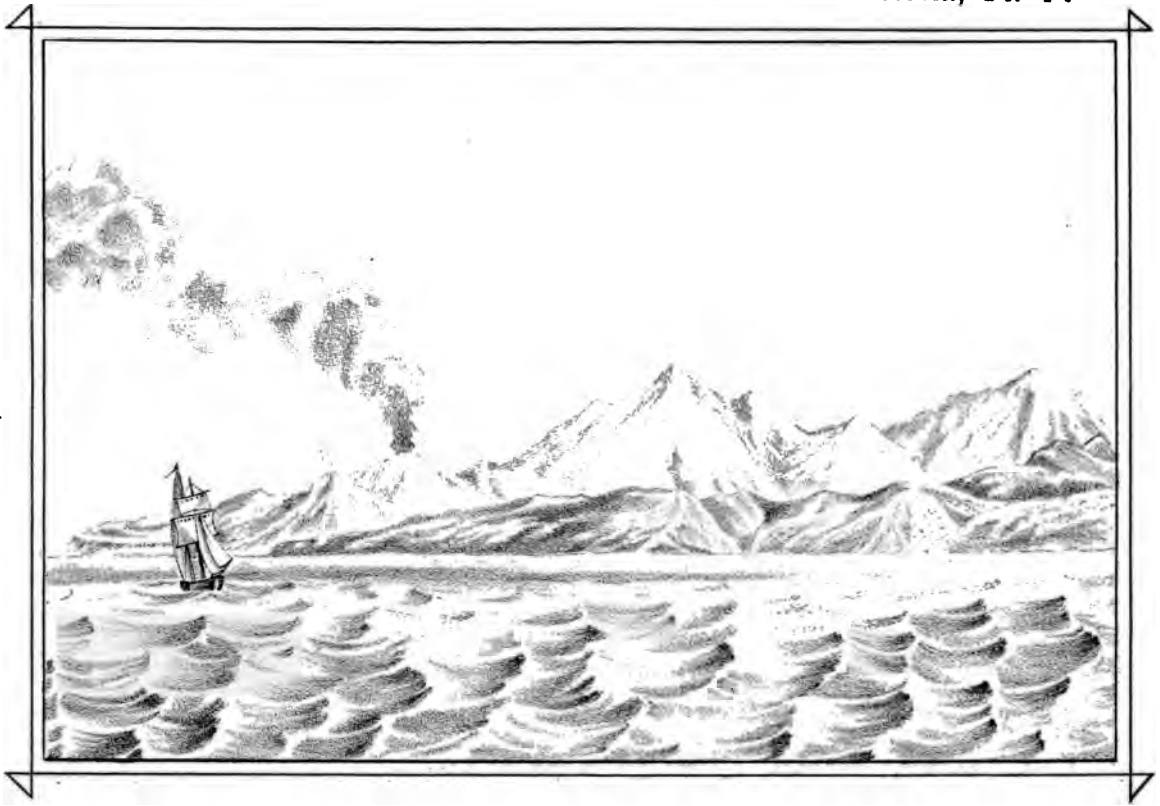

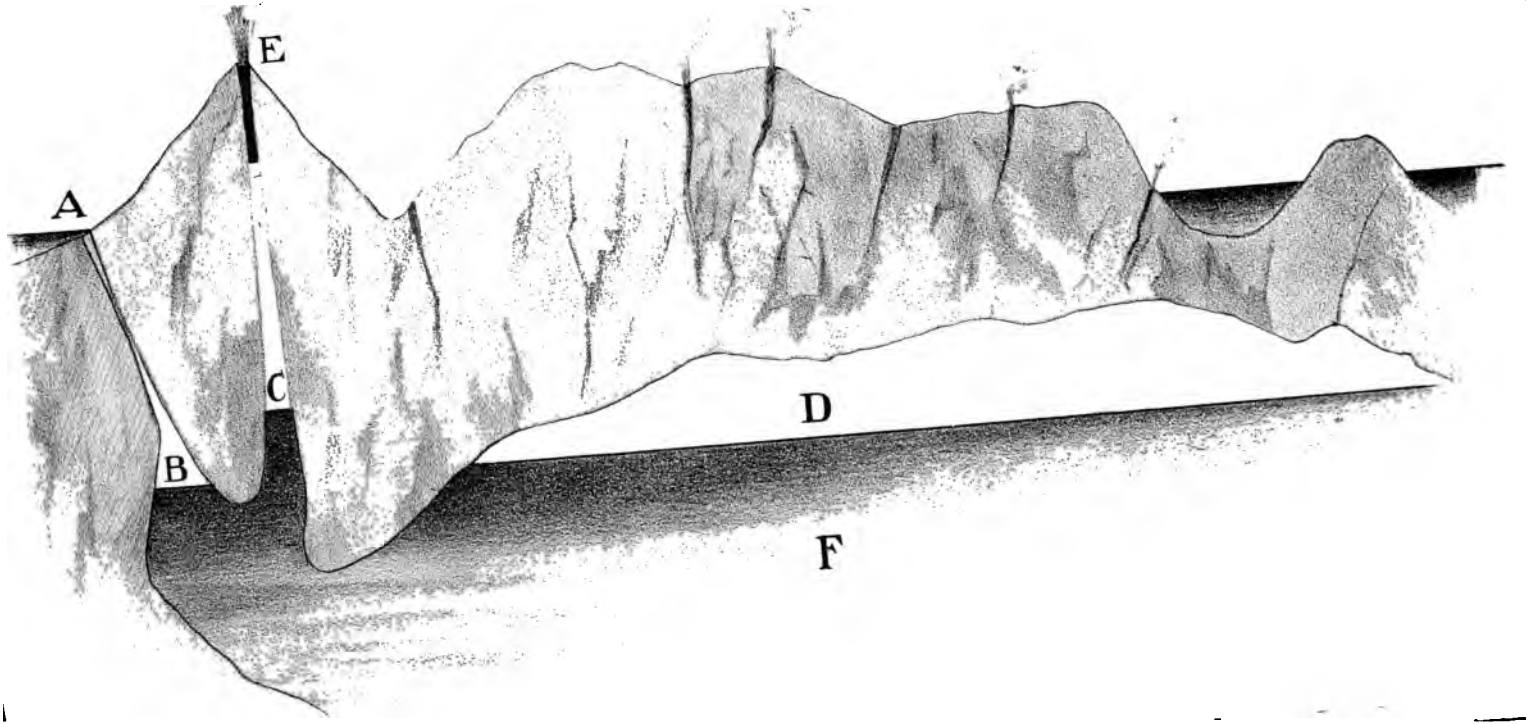
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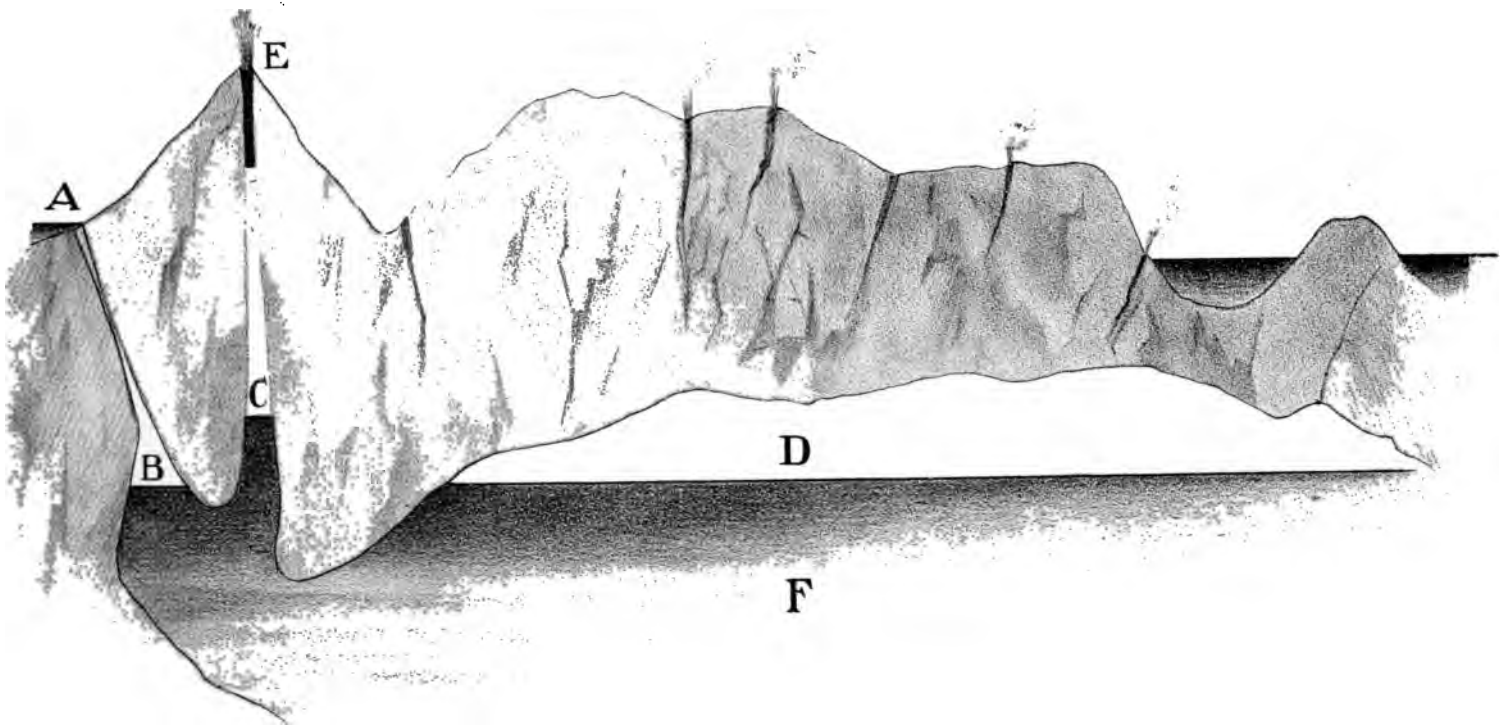
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# ART. XI.—*Notes on the Physiography of the Western portion of the County of Croajingolong.*

With two Wood-cuts.

BY JAMES STIRLING, F.G.S.

[Read Dec. 13, 1888.]

## PART I.—TOPOGRAPHY.

The extreme eastern portion of the Colony of Victoria is, perhaps the least known area within its boundaries. Having recently traversed the area in several directions, from the coast line to the colony boundary, in order to examine areas being prospected for gold, the author embraced the opportunity of making, in addition to geological observations, some notes on the native vegetation or botany, and climate or meteorology of the area, which it is hoped may serve as an introductory notice of the physiography of this little known region of Victoria.

### THE WATERCOURSES.

The principal valleys excavated from the area are the Snowy and its tributaries, and the Bemm and Cann rivers. The Snowy forms the western boundary of the county of Croajingolong, and has the largest drainage area. Rising outside the limits of the area, amid the snow-clad heights of Mount Kosciusko, the Pilot, and Mount Cobberas, at an elevation between 6000 and 7256 feet, the Snowy has eroded its passage through rock masses which may be said to present geotectonic features of great interest to the geologist, mainly, palæozoic rocks in the upper valley, and tertiary in the lower. The effects of the unequal ratios of denudation and erosion of different rock masses under similar and different climatal conditions, are strikingly exhibited in the Snowy watershed area; but as the main features lie outside the county of Croajingolong, partly in the county of Tambo, Victoria, and in the Maneroo table land in New South Wales, they cannot be properly discussed in this paper. In the Rev. W. B. Clarke's "Southern Gold Fields," and

A. W. Howitt's "Devonian Rocks of North Gippsland, will be found most interesting information on the eastern and western sources of the Snowy River. The enormous erosion of the middle portion of the Snowy Valley is plainly seen from Turnback Mountain on the old Maneroo road, or from the summit of Mount Tingiringy, near the New South Wales border. The landscape looking north from the latter mountain is perhaps the finest mountain scene in Australia—it is certainly one of grandeur. To the north, beyond the deep gorge formed by the Snowy River, rise a series of bold wooded mountains, the lower spurs of the latter almost invisible in the soft haze of the deeper portions of the valley. Beyond the wooded mountain ranges appear in silhouette the rugged porphyry heights of Mount Cobberas, the coned peak of Mount Pilot, and rising tier above tier the bold granite knobs of the Snowy Kosciusko plateau. Away to the right stretches the fine open and undulating downs of the Maneroo plateau, relieved here and there by minor ridges covered with timber, or along the creeks by belts of the Snowy River pine. While to the south the bold outlines of Mount Delegate, Mount Bowen, and the coast range, mark the sites of rock masses which have longest resisted the effects of subaerial denudation and the borderland between the jungle country of Croajingolong and the south-western extension of the Maneroo table land.

As the Snowy drains the highest elevations in Australia, and runs almost due south from their high altitudes to the coast line, its course is almost torrential throughout, except where it enters the rich alluvial flats of Orbost, where the stream becomes sluggish. To enter into a minute description of the salient points in the topography of the eastern water-shed area, would form the subject matter for an interesting paper, so varied is the surface configuration. The principal eastern source affluents drain the extensive Maneroo plateau outside the boundary of the colony, and need not be referred to. The streams within the county comprise the Deddick or Jingallala and its tributaries, the Tingiringy, Dellicknora, Cabanandra, and Bonang. There are several others which, ultimately flowing into the parent stream in New South Wales, rise in the coast range, such as the Delegate, Bendoc, Queensborough. Below the junction of the Deddick, several torrential streams enter the Snowy from the east, their courses mainly south-westerly, such as Mountain Creek, the Broadbent, Yalma, and Rodgers Rivers. Below the Orbost

flats, and near its estuary, the most important tributary the Broadribb and its affluent, the Cabbage-tree Creek, enter the parent stream. Rising in the coast range at Bonang Mountain, and running parallel with the Snowy, the Broadribb drains the western slopes of the highest points in the county, viz., Mount Ellery and the M'Culloch ranges. With the exception of some moderate extent of flats and undulatory slopes at Goonegerah in the upper portion of the valley, and the flats and morasses near its junction with the Snowy, this river intersects rangy territory of very little use for cultivation, while the tributaries are covered with dense jungle. In the heads of the Cabbage-tree Creek, St. Patrick's Creek, and other eastern affluents draining the M'Culloch ranges, is a very rich vegetable mould and soil, which may hereafter repay cultivation, although the cost of clearing would necessarily be considerable. The flats and spurs towards the coast regions are already occupied by an enterprising body of selectors, who are fast reclaiming the morass and forest lands in the vicinity.

The streams which flow southerly through the central portion of the county comprise the Bemm and Cann, with two other unimportant minor streams, the Little River and Yeerung. The Cann forms the eastern boundary of the area under consideration, and has the largest area of land available for settlement. To the north of Morgan's station, on the road to Genoa, a considerable area of flats and undulatory ranges has been selected, and west of Mount Kate there is a limited area of well grassed pasture lands awaiting settlement, and on the upper portion of the valley, as at Buldah, are other limited areas.

In the Bemm valley, as at Combinebar Creek, are rolling well grassed hills, and some rich but densely timbered flats, while several of the western affluents, as the Glen Arte River and portions of the McKenzie, present favourable areas for future settlement, although the dense jungle in the gullies and the large trees in the flats will make clearing expensive.

In the Yeerung valley towards the coast, and also in the Cabbage-tree Creek, are open heath lands which may be converted into pasture lands, especially in places where there is a coating of black, vegetable mould and clayey material overlying the sandy deposits. The area in which the cabbage palm *(Livistona Australis)* flourishes has been reserved from destruction.

## The Ranges and Mountains.

The main features of the mountain system is indicated by the courses of the principal streams. The principal watershed line is the coast range intersecting the northern portion of the county in an easterly direction and lateral ridges running southerly towards the coast from this main watershed line. The highest points on the coast range are Mount Bowen at the head of Mountain Creek, Mount Goonmurk, 4300ft., at the head of the Bemm, and Mount Tennyson on the Colony boundary towards the head of the Cann river.

The most prominent peak in the county is perhaps Mount Ellery, on the ridge dividing the Broadribb and Bemm. Viewed from the coast, the southward extension of this watershed line, the McCulloch Ranges are next in importance, while near the coast, on the ridge dividing the Broadribb and Cabbage-tree Creek, rises a rounded peak, Mount Raymond. The highest point on the divide between the Bemm and the Cann is perhaps Mount Bengow (near the Coast Range), while towards the south, nearer the coast, Mount Cann is a prominent landmark. On the eastern watershed of the Cann, Mount Kate stands high above the surrounding ranges.

The higher points on the north of the Coast Range—Mount Goolinbabylon, between the Bonang and Delegate Rivers; Mount Delegate, between the Bendoc and Delegate Rivers; and Mount Tingiringy, near the Colony boundary, between the Jingallala and Mount Richie Creek.

## Meteorology.

In looking at these mountains as a whole, and after examining the character of their rocky structure, viz., hard silicious rocks, quartzites, and indurated slates, granites, &c., the conviction is forced on the observer that they are formed by sub-aerial denudation, having longest resisted the degrading influences of the rain, frost, and snow, while the surrounding softer materials have been removed.

The difference in the amount of excavation exhibited by the south-flowing streams and those flowing northerly may, I think, be ascribed to greater precipitation of rainfall on the southern slopes, the combined influence of the south-west and south-easterly moisture-laden winds, an extension of the

warm tropical rains coming from the east north-east along the eastern Australian coast reaching the area.

In the Bendoc district, at an elevation of 2500 feet, severe frosts are not uncommon, and the range of temperature is frequently great. The snow falls annually over this area, but in the upper valleys of the Broadribb, Bemm, and Cann humidity prevails, and the temperature is more equable, frosts being far less frequent. This difference in the hygrometric and thermometric conditions produces the differences observed in the vegetation at similar elevations north and south of the coast range. And this is again very marked as the coast line is reached, so that the meteorologic conditions affect the vegetation directly. And the latter are mainly due to the varied surface configuration, resulting from the unequal decay of the different rock masses.

## BOTANY.

### Notes on the Vegetation (Peculiar Features)

The most striking feature in the vegetation of the areas examined in Croajingolong is the presence of many East Australian types not found elsewhere in Victoria, and in the luxuriance of the climbing plants The arboreous form of the Waratah (Telopea oreades) with its magnificent clusters of rich carmine-tinted flowers on terminal spikelets, surrounded by glossy sap-green leaves, at once arrests the attention of the botanical observer. Flowering during October and early in November it attains in the rich humid valleys surrounding the M'Culloch Ranges, the heads of Cabbage-tree Creek, and in the upper portions of the Bemm valley – along the coast range, &c., a height of between 40 and 50 feet.

Next to the Waratah, the profusely flowering native climbing pea (Kennedya rubicunda) is, with its brick-red blossoms, one of the most striking features, and is widely distributed over the area. In localities where it flourishes along with the native virgin's bower (Clematis aristata) and the native sarsaparilla (Kennedya monophylla), the contrasts of red, white, and blue, are most charming. Although in those places where it is interwoven with the wire grass (Ehrharta stipoides). it is the *bête noire* of the prospector or explorer. Even the dreaded thorns of the climbing lawyer (Smilax Australis) are less objection-

able than the finely serrated stems and leaves of the latter, *i.e.*, the wire grass. On the eastern tributaries of the Snowy River and in the Bemm valley, the most prolific undergrowth is that of Haloragis tetragyna or fire weed, which forms here a most useless herb, supplanting the native grasses with the exception of the scented grass—Hierochloa rariflora (a comparatively useless grass for fodder purposes, and which flourishes along with the fire weed or Haloragis tetragyna). The occurrence of the cabbage palm, Livistona Australis, on Cabbage-tree Creek, near Orbost, where it grows to a height of over 100 feet, is also a remarkable feature in the vegetation of the area. The isolation of this species from its tropical home in a humid valley in the temperate zone, require further elucidation at the hands of botanists, or of those interested in the geographical distribution of plants. I am inclined to consider it as a survival of a once tropic vegetation which covered South Eastern Australia in earlier Pliocene times, and which was destroyed by the subsequent glacial action of which there are not wanting evidences in South Eastern Australia since Miocene times.

### Numerical Proportion of the Orders.

There does not appear to be any exception to the general rule respecting the orders richest in species and genera from what prevails generally over South-Eastern Australia, except that there is a closer alliance with the flora of Southern New South Wales than with the southern and western portions of Victoria. Here, as elsewhere, the grand order—Leguminosæ, and the sub-orders—Papilionaceæ and Mimoseæ, are richest in species and genera. Comparing the different orders, we find that comprised within the list are thirty species of Leguminous plants represented by fourteen genera, that the genera richest in species are Acaciæ and Pulteneæ. Of Myrtaceæ there are twenty-nine species and nine genera, the genus Eucalyptus being richest in species. Among Compositæ there are twenty-five species and twelve genera, the Helichrysa being most abundant. Among Proteaceæ the Persoonias are richest in species. This interesting order is represented by fifteen species and seven genera. The Filices or fern-family has twenty-one species and eleven genera, the Orchids twelve species and eight genera, and the Lillies or Liliaceæ eight species and seven genera, while the Gramineæ or grasses include nine genera and species.

## Distribution of Species.

The area under examination may be said to comprise four well-marked regions, each broadly characterised by the presence of certain species of plants which impart a distinct physiognomy to the situations wherein they flourish.

If a line is drawn parallel to the coast line at a distance of 6 miles, it will be found that up to an elevation of 300 feet above sea level the vegetation differs from that found in the gullies and valleys further inland up to the flanks of the coast range to, say 4000 feet elevation; that the crests of the ridges within the middle area contain species not found in the gullies; and that in the more open table land north of the coast range there are abundance of sub-alpine species not found in any of the other areas or situations.

## The Coastal Regions.

Along the sand hammocks, Salsolaceæ and Ficoideæ prevail —Rhagodia, Chenopodium, Atriplex, and Mesembrianthemum (or pig's face); and in the hollows, such Myrtaceous shrubs as Melaleuca armillaris, Kunzea corifolia, Leptospermum myrsinoides; and grasses, as Zoysia pungens. In the open undulating coastlands, between belts of Eucalyptus, including the mahogany E. botryoides and abundance of Banksia serrata, are grass-tree flats with Xanthorrea Australis, and X. minor—the dwarfed sheoak, Casuarina paludosa, in the undulating sand hills, where the timber vegetation is more prolific, an abundance of Caustis flexuosa and Lycopodium densum, Ricinocarpus pinifolius, and other shrubby and herbaceous species, together with a great number of species less peculiar to the coastal areas as Epacris impressa, Hibbertias, Styphelias. To enumerate them would extend this paper to an unusual length.

## Inland Region.—Gullies and River Flats.

The most arboreous vegetation is found in the moist gullies and on the river flats, and with the exception of the hollows or lowest points in the ridges yields characteristic forms, differing from those on the ridges. Among many such arboreous forms may be mentioned the Waratah (Telopea oreades), the native musk (Aster argophyllus), Lillypillies,

(Eugenia Smithii), native pepper tree (Drimys aromatica), the native sassafras (Atherosperma moschatum), native firewood (Hedycarya Cunninghami), Pittosporum undulatum, P. bicolor, Zieria Smithii, Acacia decurrens, A. melanoxylon, Eucalyptus amygdalina, E. pilularis, E. longifolia, and others; Prostanthera lasiantha, Lomatia ilicifolia, Sambucus Gaudichaudiana; and such creepers as Lyonsia stramina, Smilax Australis, Vitis hypoglauca, &c., and Sarcopetalum Harveyanum, Rubus rosifolius.

### Ridges.

On the heads of gullies and lower points of the ridges—Eriostemon trachyphyllus, Senecio Bedfordii, Correa Lawrenciana, Dodoneas, Oxylobium ellipticum, Hovea longifolia, Indigofera Australis, Goodia lotifolia, and several Acacias, Eucalypts, Pomaderris, Panax, Persoonia, Lomatia longifolia, Pimelea, Coprosma hirtella, Asters, Notelea lanceolata, Solanum, Helichrysum obcordatum, Cassinia aculeata, Helichrysum cuneifolium, and others.

### The Sub-Alpine or Table-land Areas.

Here in the open grassy valleys and woodlands are found, between 2500 and 4000 feet, numerous species, which extend over large areas in the Australian Alps, patches of Stellaria pungens, fine undershrubs, as Oxylobium procumbens, Mirbelia, Pulteneas, Persoonia Chamaepeuce, Hakea microcarpa, Pimelia ligustrina, Brachycomes, Aster megalophyllus, Lagenophora Billardieri; Helichrysums, as H. apiculatum, H. semipapposum, Gnaphalium Traversii, Gentiana saxosa, Euphrasia Brownii, Ajuga Australis, Styphelia Macraei, Epacris microphylla; Diplarrhena Moraea, and many others Around Bonang the latter attains its richest luxuriance at an elevation of 2000 feet, although it also flourishes in the river flats towards the coast line as at Goonegerah and Cann.

### Territorial Range of Species.

Here, as elsewhere, the gum trees have the greatest territorial range, and magnificent forests of splendid splitting timber exists, notably on the flanks of the McCulloch Range

in the Broadribb and Bemm watersheds, and along the south side of the coast range in the heads of the Bemm and Cann rivers. While it is patent, that many of the giant gums exceed a height of 350 feet, I have not yet observed any over 400 feet; if there are any exceeding the latter length, it is probably in the Arte, Goolingook, or Cabbage-tree Creek valleys that they will be met with. The tallest trees are not always those with the greatest diameter of trunk. I have certainly measured trunks fully 40 feet in circumference, but as a rule the taller trees measured had a lesser circumference of from 20 to 30 feet. Next to the Eucalypts the Acacias have the greatest range, and after these the Daviesias, Haloragis tetragyna, Comesperma ericinum, and Kennedya rubicunda, together with the wire-grass.

## The Evolution of Varietal Forms.

Between the summits of the higher peaks, Mount Ellery, Mount Kate, Mount Goonmurk, on the Coast Range, Mount Tingiringy north of it and the coast line, there are considerable variations in the hygrometric and other meteorologic conditions, which I believe so powerfully affect the evolution of varietal forms. I have elsewhere* endeavoured to point out as regards the Alpine and sub-Alpine florula of South-East Australia that under the slowly changing surface configuration, due to prolonged sub-aerial denudation and erosion, the transfer of soils, abraded and decomposed from the great rock masses, and the action of their chemical constituents on plant, food, &c., gradually modifying its environment, may eventually result in the differentiation of the varieties as to assume characters so distinct and apparently constant as to justify the appelation of species. Among many species which present differential characters over large areas in different habitats, I would mention Craspedia Richea, Daviesea latifolia; some Helichrysa, especially Helichrysum rosmarinifolium; some Rutaceæ, Drimys aromatica, Hymenanthera Banksii, Claytonia Australasica, Panax sambucifolius, Gentiana saxosa, Styphelia ericoides, and Microseris Forsteri.

* On the Physiography of the Australian Alps. Transactions of Australian Association for Advancement of Science, 1888.

LIST OF SPECIES OF PLANTS COLLECTED IN THE AREA, AND ARRANGED ACCORDING TO BARON VON MUELLER'S CLASSIFICATORY SYSTEM, "SYSTEMATIC CENSUS OF AUSTRALIAN PLANTS."

*Ranunculaceæ* (A. L. de Juss.)

Ranunculus aquatilis (Dod.) Orbost.
„ lappaceus (Sm.) Orbost and Bendoc.
„ rivularis (Bks.) Orbost.
Clematis aristata (R. Br.) Orbost, Broadribb, & Coast Range.

*Dilleniaceæ* (Salsb.)

Hibbertia Billardieri (F. v. M.) Cann River.
„ dentata (R. Br.) Goolingook River.

*Magnoliaceæ* (J. de St. Hil.)

Drimys aromatica (F. v. M.)
Coast Range and Goolingook Valley; tree 20 to 30 ft. high.

*Menispermeæ.*

Stephania hernandifolia (Walp.) Cann Valley.
Sarcopetalum Harveyanum (F. v. M.) Lower Snowy River.

*Monimieæ* (A. L. de Juss.)

Atherosperma moschatum (Labill.)
Forms dense forests along Coast Range; at Mt. Goonmurk, trees are 120 feet to 150 feet high, with trunks 6 feet in diameter.
Hedycaria Cunninghami (Tulasne).
Mt. Goolinbabylon and Coast Range.

*Lauraceæ* (Vent.)

Cassytha pubescens (R. Br.) Upper Cann Valley.
„ melantha (R. Br.) Broadribb and Orbost.

*Cruciferæ* (A. L. de Juss.)

Cardamine hirsuta (Linn.) Bendoc.

*Violaceæ* (De Cand.)

Viola hederacea (Labill.) Orbost.
„ Caleyana (Don.) Bendoc and Orbost.
Hymenanthera Banksii (F. v. M.) Broadribb and Cann.

*Pittosporeæ* (R. Br.)

Pittosporum undulatum (Andr.)
Snowy, Broadribb, Bemm, and Cann Rivers, near Coast.

Pittosporum revolutum (Aitn.) Cann Valley.
„ bicolor (Hook.)
Bursaria spinosa (Cav.) Broadribb and Cann.
Marianthus procumbens (Benth.) Broadribb and Orbost.
Billardiera scandens (Smt.) Cann and Orbost.

*Droseraceæ* (Sals.)

Drosera auriculata (Bach.) Orbost and Cann.

*Polygaleæ* (A. L. de Juss.)

Comesperma ericinum (De Cand.) Orbost and Benn.
„ volubile (Labill.)
Orbost, Broadribb, Cann and Bemm Valleys.
Very aromatic, like true sarsaparilla root, and can be used as an alterative.
Comesperma defoliatum (F. v. M.) Broadribb River.

*Tremandreæ* (R. Br.)

Tetratheca ciliata (Linn.)
Very abundant on eastern tributaries of Snowy River.

*Rutaceæ* (A. L. de Juss.)

Zieria Smithii (Andr.) Coast Range, Cann, & Bemm Valleys.
Eriostemon trachyphyllus (F. v. M.)
Upper Bonang and Broadribb Valleys.
Correa Lawrenciana (Hook.) M'Culloch Ranges, Bonang.
„ speciosa (Andr.) Coast region.

*Lineæ* (De Cand.)

Linum marginale (Cunn.) Orbost.

*Geraniaceæ* (A. L. de Juss.)

Pelargonium Australe (Willd.) Coast region.

*Malvaceæ* (Adanson).

Howittia trilocularis (F. v. M.) Orbost.

*Sterculiaceæ* (Vent.)

Brachychiton populneum (R. Br.) Broadbent River.
Commersonia Frazeri (J. Gay) Cann Valley.
Lasiopetalum dasyphyllum (Sieb.)
Coast Range, Broadribb Valley.

*Tiliaceæ* (A. L. de Juss.)

Elæocarpus holopetalus (F. v. M.)
Broadribb, Bemm, Cann, Bonang, and Mt. Goonmurk.

*Euphorbiaceæ* (A. L. de Juss.)

Micrantheum hexandrum (Hook.) — Cann Valley.
Ricinocarpus pinifolius (Desfont.) — Broadribb, near Coast.
Bertya Cunninghamii (Planch.) — Snowy River.
Amperea spartioides (Brong.) — Broadribb River.
Phyllanthus thymoides (Sieb.) — Cann and Bemm Rivers.
,, Gunnii (Hook.) — Broadribb.
Adriana acerifolia—tomentosa—(Hook.) — Snowy River.

*Casuarineæ* (Mirb.)

Casuarina paludosa. — Marlow.
,, distyla (Vent.) — Orbost.

*Viniferæ* (I. de St. Hil.)

Vitis hypoglauca (F. v. M.) — Broadribb, Bemm, and Cann Valleys.

*Sapindaceæ* (A. L. de Juss.)

Dodonæa viscosa (Linn.) — Broadribb.

*Stackhousieæ* (R. Br.)

Stackhousia linarifolia (Cunn.) — Orbost.

*Portulaceæ* (A. L. de Juss.)

Claytonia Australasica (Hook.) — Bendoc.

*Caryophylleæ* (Linn.)

Stellaria pungens (Brong.) — Bendoc.
,, flaccida (Hook.) — Bemm and Cann Valleys.

*Salsolaceæ* (Linn.)

Rhagodia Billardieri (R. Br.) — Coast Region.
Chenopodium murale (Linn.) — Cann, towards Coast.
,, glaucum (Linn.) — Coast Region.
Atriplex crystallinum (Hook.) — Coast, Snowy River.

*Ficoideæ* (A. L. de Juss.)

Mesembrianthemum æquilaterale (Haw.) — Sand Hammocks.

*Polygonaceæ* (A. L. de Juss.)

Mühlenbeckia axillaris (Hook.) — Snowy River.

*Leguminoseæ*, sub order *Papilionaceæ*.

Oxylobium ellipticum (R. Br.) — Glen Arte River, Coast Range.

| | |
|---|---|
| Oxylobium procumbens (F. v. M.) | Mt. Tingiringy. |
| Mirbelia oxyloboides (F. v. M.) | Near Bendoc. |
| Gompholobium Huegelii (Benth.) | Delegate & Bonang Rivers. |
| Daviesia latifolia (R. Br.) | Orbost. |
| „ ulicina (Sm.) | Delegate River. |
| Aotus villosa (Sm.) | Broadribb. |
| Pultenea daphnoides (Wend.) | Bemm Valley. |
| „ retusa (Sm.) | Broadribb. |
| „ juniperina (Labill.) | Bonang. |
| „ fasiculata (Benth.) | Cann Valley. |
| Platylobium obtusangulum (Hook.) | Orbost. |
| Bossiæa buxifolia (Cunn.) | Cann Valley. |
| „ microphylla (Sm.) | Orbost. |
| Hovea longifolia (R. Br.) | Broadribb. |
| Goodia lotifolia (Sals.) | Broadribb, Bemm, and Cann Valleys. |
| Indigofera Australis (Willd.) | Goolingook, Bonang River. |
| Glycine clandestina (Wend.) | Orbost and Broadribb. |
| Kennedya rubicunda (Vent.) | All over Middle of County. |
| „ monophylla (Vent.) | Orbost, Bonang, &c. |

Sub order, *Mimoseæ.*

| | |
|---|---|
| Acacia juniperina (Willd.) | Cann Valley. |
| „ vomeriformis (Cunn.) | Cann. |
| „ stricta (Willd.) | Cann. |
| „ penninervis (Sieb.) | Cann and Snowy. |
| „ pycnantha (Benth.) | Broadribb Valley. |
| „ myrtifolia (Willd.) | Cann Valley. |
| „ linearis (Sims). | „ |
| „ melanoxylon (R. Br.) | Broadribb, Bemm, and Cann. |
| „ longifolia (Willd.) | Cann Valley. |
| „ decurrens (Willd.) | Cann, Bemm, and Broadribb. |

*Rosaceæ* (A. L. de Juss.)

| | |
|---|---|
| Rubus parvifolius (Linn.) | Orbost. |
| „ rosifolius (Sin.) | Orbost, near Marlow. |

*Saxifrageæ* (Vent.)

Bauera rubiodes (Andr.)
All over the Bemm Valley and around Orbost.

*Crassulaceæ* (De Cand.)

Tillea verticlilaris (De Cand.) Orbost.

*Onagreæ.*

Epilobium tetragonum (Linn.) Bendoc and Snowy River.

*Salicariecæ* (Adanson).

Lythrum Salicaria (Linn.)
Broadribb and Snowy River, on marshy flats.

*Haloragecæ* (R. Br.)

Haloragis heterophylla (Brogn.) Snowy River.
„ tetragyna—fire weed—(R. Br.)
All over the County; a useless weed, replacing the grasses over large areas.
Myriophyllum elatinoides (Gaud.) Delegate River.

*Myrtacecæ* (Adanson).

Baeckea virgata (And.) Snowy River.
Leptospermum lanigerum (Sm.) Coast Regions.
„ myrsinoides (Schlech.) „
Kunzea peduncularis (F. v. M.) Upper Snowy River.
„ corifolia (Reich.) Coast Regions.
Angophora intermedia (De Cand.) Cann Valley.
Eucalyptus stellulata (Sieb.) Bendoc.
„ capitellata (Sm.) Bemm, Cann, and Broadribb.
„ pauciflora (Sieb.)
Mounts Ellery, Tingiringy, and Delegate.
„ amygdalina (Labill.) Cann and Bemm Valleys.
„ obliqua (F. v. M.) Broadribb River.
„ piperita (Sm.)
Mount Goonmurk and Cann Valley.
„ melliodora (Cunn.) Cann and Snowy Rivers.
„ longifolia. Coast Regions, Cann, and Bemm.
„ botryoides (Sm.) Snowy and Broadribb.
„ tereticornis (Sm.) Snowy River.
„ Stuartiana (F. v. M.) Bendoc.
„ Gunnii (Hook.) Mount Goonmurk.
„ eugenioides (Sieb.) Bendoc and Cann Valley.
„ robusta (Sm.) „ „
„ pilularis (Sm.) Broadribb and Bemm.
„ macrorrhyncha (F. v. M.) Orbost.
„ Sieberiana (F. v. M.) Coast Range.
„ hemiphloia (F. v. M.) Snowy River.
Tristania laurina (R. Br.) Bemm Valley.
Eugenia Smithii—Lilly pillies—(Poir.)
Snowy River, Orbost.

*Rhamnaceæ* (A. L. de Juss.)

| | |
|---|---|
| Pomaderris elliptica (Labill.) | Broadribb. |
| „ apetala (Labill.) | Bemm and Broadribb. |
| „ prunifolia (A. Cunn.) | Near Coast, Snowy River. |
| Discaria Australis (Hook.) | Upper Snowy River. |

*Araliaceæ* (Vent.)

| | |
|---|---|
| Astrotricha ledifolia (De Cand.) | Cann Valley. |
| Panax sambucifolius (Sieb.) | |
| (*a*) Var. with broad leaves. | Cann Valley. |
| (*b*) „ with narrow pinnate foliage. | Bemm and Broadribb. |

*Umbelliferæ.*

| | |
|---|---|
| Trachymeme Billardieri (F. v. M.) | Broadribb, on ridges. |
| Crantzia lineata (Nutt.) | Snowy River (entrance). |

*Santalaceæ* (R. Br.)

| | |
|---|---|
| Leptomeria aphylla (R. Br.) | Bonang. |
| Omphacomeria acerba (De Cand.) | Cann. |
| Exocarpus cupressiformis (Labill.) | Cann, Bemm, Broadribb. |
| „ stricta (R. Br.) | Goonegrah and Cann. |

*Proteaceæ* (A. L. de Juss.)

| | |
|---|---|
| Conospermum patens (Sch.) | Bendoc. |
| Persoonia confertiflora (Benth.) | Cann and Marlow. |
| „ linearis (Andr.) | Snowy River, Orbost. |
| „ Chamæpeuce (Lhot.) | Yeerung River. |
| „ lanceolata (Andr.) | Bonang. |
| „ juniperina (Labill.) | Cann. |
| Grevillia ericifolia (R. Br.) | Cann River. |
| „ parviflora (R. Br.) | Broadribb. |
| Hakea eriantha (R. Br.) | Broadribb and Cann. |
| „ microcarpa (R. Br.) | Orbost. |
| Telopea oreades (F. v. M.) | |
| Broadribb, Cann, Bemm, Cabbage Tree Creek, Coast Range near Bombay. | |
| Attains a height of 50 feet in humid valleys near McCulloch Ranges. | |
| Lomatia longifolia (R. Br.) | Coast Range. |
| „ ilicifolia (R. Br.) | Cann River and Orbost. |
| Banksia serrata (Linn.) | Coastal Regions. |
| „ collina (R. Br.) Shrubby species | Near Cann. |

*Thymeleæ.*

Pimelea ligustrina (Labill.) Mount Goonmurk and Coast Range.
„ axiflora (F. v. M.) Bendoc River.
„ sp. Orbost.

*Rubiaceæ.*

Coprosma Billardieri (Hook.) Cann and Orbost.
„ hirtella (Labill.) Bonang.
Morinda jasminoides (A. Cunn.) Broadribb and Snowy.

*Compositæ.*

Brachycome decipiens (Hook.) Bonang and Orbost.
Aster megalophyllus (F. v. M.) Delegate River.
„ argophyllus (Labill.) Coast Range and streams flowing South.
„ stellulatus (Labill.) Bemm Valley.
(Var. quercifolia.)
„ iodochrous (F. v. M.) Snowy River, Orbost, Cann, &c.
Calotis lappulacea (Benth.) Snowy River and Orbost.
Lagenophora Billardieri (Cass.) Bendoc.
Podolepis acuminata (R. Br.) Bendoc.
Helipterum anthemoides (De Cand.) Mount Delegate.
Helichrysum scorpioides (Labill.) Bonang.
„ bracteatum (Willd.) Coast Range.
„ leucopsidium (De Cand.) Broadribb.
„ apiculatum (De Cand.) Bendoc and Orbost.
„ semipapposum (De Cand.) Bendoc and Bonang.
„ rosmarinifolium (Less.) Delegate River.
(Var. thyrisoides.)
„ obcordatum (F. v. M.) Mount Buck.
„ cuneifolium. „
Cassinia aculeata (R. Br.) Bonang and Delegate Rivers.
Humea elegans (Sm.) Broadribb.
Gnaphalium Traversii (Hook.) Craigie Bog.
Craspedia Richea (Cass.) Bendoc and Orbost.
Senecio spathulatus (A. Rich.) Orbost.
„ lautus (Sol.) Bemm Valley.
„ Australis (A. Rich.) Snowy River.
„ Bedfordii (F. v. M.)
Broadribb, Bemm and Cann, Coast Range, Bonang.

*Caprifoliaceæ.*

Sambucus Gaudichaudiana (De Cand.) Orbost.

*Campanulaceæ* (A. L. de Juss.)

Lobelia purpurascens (R. Br.) — Snowy River.
Wahlenbergia gracilis (A. de Cand.) — Orbost.

*Candolleaceæ* (R. Br.)

Stylidium graminifolia (Swartz.) — Orbost.

*Goodeniaceæ* (R. Br.)

Goodenia paniculata (Sm.) — Snowy River.
Scævola hispida (Cav.) — Broadribb and Bemm.
Dampiera stricta (R. Br.) — Goolingook Ranges and Orbost.

*Gentianeæ* (B. de Juss.)

Limnanthemum crenatum (F. v. M.) — Delegate River.
Gentiana saxosa (Forst). — Mount Goonmurk.

*Primulaceæ* (Vent.)

Samolus Valerandi (Linn.) — Orbost.

*Myrsinaceæ* (R. Br.)

Myrsine variabilis (R. Br.) — Snowy, Broadribb, Bemm, and Cann Rivers.

*Jasmineæ* (A. L. de Juss.)

Notelæa lanceolata (Vent.) — Sardine Creek Ridges.

*Apocyneæ* (A. L. de Juss.)

Lyonsia straminea (R. Br.) — Bonang, Broadribb.

*Asclepiadeæ* (Jacq.)

Tylophora barbata (R. Br.) — Snowy River.
Marsdenia rostrata (R. Br.) — Broadribb.

*Convolvulaceæ* (A. L. de Juss.)

Convolvulus erubescens (Sims). — Orbost, Bonang.
„ marginatus (Poir.) — Broadribb & Snowy Rivers.

*Solanaceæ* (Hall.)

Solanum vescum (F. v. M.) — Bonang, Orbost.
„ aviculare (Forst.) — Snowy River.
„ pungetium (R. Br.) — Broadribb River.

*Scrophularinæ* (Mirb.)

| | |
|---|---|
| Gratiola Peruviana (Linn.) | Snowy and Bonang Rivers. |
| Veronica Derwentia (Andr.) | Orbost. |
| „ perfoliata (R. Br.) | Bonang and Delegate. |
| Euphrasia Brownii (F. v. M.) | Bendoc. |

*Labiatæ* (Adanson).

| | |
|---|---|
| Mentha laxiflora (Benth.) | Snowy River. |
| Plectranthus parviflorus (Willd.) | Broadribb and Snowy. |
| Salvia plebeja (R. Br.) | Broadribb and Snowy. |
| Prostanthera lasiantha (Labill.) | Coast Range, Bonang. |
| Teucrium corymbosum (R. Br.) | Upper Bemm Valley. |
| Ajuga Australis (R. Br.) | Orbost and Bonang. |

*Myoporinæ* (R. Br.)

| | |
|---|---|
| Myoporum floribundum (Cunn.) | Orbost and Bonang. |

*Epacrideæ* (R. Br.)

| | |
|---|---|
| Styphelia lanceolata (Sm.) | Cann River. |
| „ Macraei (F. v. M.) | Cann and Upper Bemm. |
| Epacris impressa (Labill.) | Marlow. |
| „ microphylla (R. Br.) | Bendoc. |

*Orchideæ* (Hall.)

| | |
|---|---|
| Dipodium punctatum (R. Br.) | Broadribb Valley. |
| Spiranthes Australis (Linn.) | Broadribb Valley, Snowy River. |
| Thelymitra ericoides (Sm.) | Snowy River. |
| „ longifolia (Forst.) | Orbost |
| Diuris punctata (Sm.) | „ |
| „ pedunculata (R. Br.) | „ |
| „ longifolia (R. Br.) | Cann. |
| Cryptostylis longifolia (R. Br.) | Orbost. |
| Pterostylis nutans (R. Br.) | „ |
| Caladenia Patersoni (R. Br.) | Cann. |
| „ carnea (R. Br.) | Bonang. |
| Glossodia minor (R. Br.) | Cann and Bemm. |

*Irideæ* (Vent.)

| | |
|---|---|
| Diplarrhena Moraea (Labill.) | Broadribb, Bonang, Orbost, and Snowy Rivers. |
| Patersonia glabrata (R. Br.) | Snowy River, Marlow. |
| Sisyrinchium paniculatum (R. Br.) | „ „ |

*Liliaceæ* (Hall.)

| | |
|---|---|
| Smilax Australis (R. Br.) | Bonang and Snowy Rivers. |
| Rhipogonum album (R. Br.) | Snowy River. |
| Eustrephus latifolius (R. Br.) | ,, |
| Thysanotus tuberosus (R. Br.) | Cann and Broadribb. |
| Stypandra glauca (R. Br.) | Orbost. |
| Xerotes longifolia (R. Br.) | Goonegerah and Marlow. |
| Xanthorrhœa minor (R. Br.) | Coast Regions. |
| ,, Australis (R. Br.) | ,, |

*Palmæ* (Ray).

| | |
|---|---|
| Livistona Australis (Mart.) | Cabbage Tree Creek. |

*Typhaceæ* (A. L. de Juss.)

| | |
|---|---|
| Typha angustifolia (Linn.) | Snowy River. |

*Juncæ* (R. Br.)

| | |
|---|---|
| Luzula campestris (De Cand.) | Orbost. |

*Restiaceæ* (R. Br.)

| | |
|---|---|
| Centrolepis strigosa (Roe). | Snowy River. |
| Leptocarpus Brownii (Hook.) | ,, |

*Cyperaceæ* (Hall.)

| | |
|---|---|
| Cyperus lucidus (R. Br.) | Orbost. |
| Schœnus axillaris (Poir.) | ,, |
| Caustis flexuosa (R. Br.) | Coast Region, Cann. |

*Gramineæ* (Hall.)

| | |
|---|---|
| Panicum marginatum (R. Br.) | Snowy River. |
| Oplismenus compositus (Pal.) | Broadribb. |
| Zoysia pungens (Willd.) | Coast Region. |
| Anthistiria ciliata (Linn.) | Broadribb. |
| Hierochloa rariflora (Hook.) | |
| (Scented grass.) | |
| All over the Broadribb, Snowy, Cann, Bemm, and Bonang Valleys. | |
| Pappophorum commune (F. v. M.) | Snowy River. |
| Poa cæspitosa (Forst). | Broadribb Valley. |
| Agropyron pectinatum (Pal.) | Snowy River. |
| Erharta stipoides (Labill.) | All over the area. |
| (Wire grass.) | |

*Lycopodineæ* (Swartz.)

| | |
|---|---|
| Phylloglossum Drummondii (Kunze) | Cann. |
| Lycopodium clavatum (Linn.) | Snowy River. |
| „ densum (Labill.) | Cann River. |

*Filices* (Linn.)

| | |
|---|---|
| Gleichenia circinata (Swartz.) | Bonang. |
| „ flabellata (R. Br.) | Yalma River. |
| Todea Africana. | Broadribb, Bonang. |
| Dicksonia antarctica (Labill.) | McCulloch Ranges, Broadribb, Cann, Bemm. |
| Adiantum Aethiopicum (Linn.) | Orbost. |
| Adiantum formosum (R. Br.) | Broadribb and Snowy. |
| Pteris falcata (R. Br.) | Bemm, Cann, and Broadribb |
| „ tremula (R. Br.) | Snowy River. |
| „ aquilina (Linn.) | „ |
| Lomaria discolor (Willd.) | Orbost, Bonang, Bemm, and Broadribb. |
| „ capensis (Willd.) | Bonang, Mt. Goonmurk. |
| Blechnum cartilagineum (Swartz.) | Broadribb and Cabbage Tree Creek. |
| Doodia aspera (Mett.) | Broadribb and Snowy Rivers. |
| Asplenium trichomanes (Linn.) | Rodgers River. |
| „ flabellifolium (Cav.) | Bendoc. |
| „ bulbiferum (Forst.) | Bonang. |
| „ umbrosum (J. Sm.) | Snowy and Broadribb. |
| Aspidium aculeatum (Swartz.) | Snowy River. |
| „ decompositum (Spreng.) | „ |
| Polypodium punctatum (Thun.) | Broadribb and Snowy. |
| „ serpens (Forst.) | Cabbage Tree Creek, Broadribb, Orbost. |

## The Geological Structure.

The rocks of the western portion of Croajingolong do not present many peculiar features. In the upper portion of the area, silurian slates and sandstones prevail; in the middle, a belt of granite stretches across from east to west; and towards the coast, are pliocene bouldery deposits overlying occasional outliers of partially denuded miocene gravels, clays, and limestone bands.

Infolded with the Silurian are occasional outliers of conglomerate shales and limestone bands, and some patches of tertiary basalt. Towards the Cann Valley are masses of

brown and red sandstones and conglomerates, and grits apparently Devonian; while still further eastward towards the colony boundary are some yellow sandstones and grits bearing a striking resemblance to the lower members of the N.S.W. carboniferous series. The localities where each group of rock formations are found may be best described by taking each group according to stratigraphical succession.

## Sedimentary Rocks.

### *Lower Silurian.*

The oldest sediments observed are the black slates of the eastern tributaries of the Snowy, as at Deddick and at the Yalma, where graptolites occur. These black slates are vertical and finely laminar, and are evidently lower Silurian. So far as known at present, these black graptolitic slates do not extend further to the eastward. At Bonang they are replaced by ash-coloured and brownish shales and grey quartzites, and at Bendock by fawn-coloured, pinkish, and yellowish slates, shales, and fine-grained felsitic sandstones with a lesser angle of dip by from 50° to 80°. In the Broadribb Valley, the sediments are more indurated, and have suffered much contortion, as seen on the range dividing the Broadribb and Sardine Creeks, northerly from Mount Buck, where they consist of brown, indurated sandstones, and flexured hard slates full of quartz segregations. On the Black Watch Creek and Goolingook the slates are blue and more persistent in strike, with interlaminated bands of grey close-grained quartzite. The former resemble upper Silurian sediments, while the latter the lower. No line of demarcation has yet been found within the area. The lithological characters and angle of dip are not sufficient to determine a stratigraphical horizon. The induration of much of the sedimentary masses is evidently due to the intrusion of granite masses either as bosses *in situ* or ramifying dykes of hornblende (diorite) rock associated with the intrusive masses.

### *Upper Silurian.*

On the range dividing the Broadribb and Snowy Rivers at the head of Sardine Creek (northern branch) is a band of greyish and whitish marble and masses of coarse conglomerates and jointed shales. The marble band yields some stems of Actinocrinus of apparently upper Silurian facies. The con-

glomerates are lithologically similar to certain beds lying at the base of the middle Devonian elsewhere, as at Bendi ;* and also to some outliers at Giblo River† They may, I think, be provisionally classed as upper Silurian.

### *Devonian.*

On the divide between the Bemm and Cann, the eastern watershed of the Combinebar Creek, and at Buldah, are masses of quartzose conglomerate and red sandstones, presenting in places a low angle of dip 30° to 60°, presenting similar features to the Devonian sandstones and conglomerates of Mount Tambo.‡ They are certainly stratigraphically superior to the slates and sandstones of the Yalma and Bendoc, and may be provisionally classed as Devonian. Like the former, they have been subjected to the indurating effects of adjacent granite masses occupying the lower part of the Cann valley. The sandstones being converted into quartzites, and the conglomerates into porphyries or porphyritic conglomerate, I cannot assign any age to these masses ; they may represent upper Devonian. All that can be safely said in the absence of fossils is, that they are younger than any members of the upper Silurian, and are overlaid further to the east by what appears to be an outlier of carboniferous sandstone. The latter will be referred to in a subsequent paper on the "Physiography of the Eastern Portion of the County of Croajingolong," for which I am preparing data.

### Plutonic.

From the Cabanandara valley, and also at Bonang and the Delegate River north of the coast range, a mass of granite stretches through the centre of the county to the Cann River at Morgan's homestead—Mount Ellery is the centre of this broad band of granite. A huge tor, occupying the highest point of the mountain, forms a prominent feature in the landscape. From the induration and metamorphism which this plutonic mass has effected along its margin, it is younger than any of the palæozoic sediments. At Bonang it is a ternary compound of glassy quartz, white and greyish

* Notes on the Physiography of the Tambo Valley. J. Stirling, in Transactions Geological Society of Australasia, 1887.

† Notes on the Giblo River Tableland. J. Stirling, in Mining Reports for September, 1887.

‡ On the Devonian Rocks of North Gippsland. By A. W. Howitt, F.G.S. Government Report Geological Survey of Victoria.

orthoclase felspar, and greenish mica. The upper portion of the mass has a gneissose appearance, as if the mass had been subject to lateral strain and crushing, causing re-arrangements of the constituents subsequent to its original solidification from a plastic molten mass.

To the south as at Sardine Creek, on the Broadribb, the middle portion of the Erinundra, on the Bemm, the heads of Tongii Creek, and on the Cann at Morgan's, it has accessory hornblende in places, is in fact syenitic. The age of these granitic masses is probably Devonian: they form part of the plutonic masses which invaded the Palæozoic sediments at the close of the Devonian period, and exposed by subsequent denudation.

At the Yeerung River are masses of quartz, porphyry, and felsites, also probably part of the later Devonian volcanic activities. So far as known at present, the Mesozoic series are absent.

### Tertiary.—Miocene.

The next defined group of rocks are the yellow limestone bands resting on the denuded surfaces of the Silurian or granite rocks, and overlaid by bouldery wash clays, gravels, and sand deposits. This formation is found near the coast, well exposed cliffs are seen on the west side of the Snowy near Orbost, and occasional remnants are met with on the east side, yielding characteristic fossils.

At Bonang, and in certain places along the western watershed of the Broadribb River, are outliers of tertiary basalt which appear to have filled the Miocene River valleys although the surrounding hills have been degraded. At Bonang, underlying the basalt there and on the western rim, are outcrops of what at first would be considered a heavy river bouldery deposit. Further close examinations suggested to me that it was in reality a remnant of a Devonian conglomerate (some of the waterworn boulders are 3 feet in diameter). The locality is about 450 feet above the Bonang river.

Unless these boulders are, as suggested, remnants of Devonian heavy conglomerates (they are probably of glacial origin), it is difficult to conceive of fluviatile agencies transporting them along a comparatively flat valley such as existed *in situ* during Miocene times. A little gold has been obtained in some of the lighter gravelly wash associated with the larger boulders.

### Metamorphic.

On the McCulloch Ranges, running south from Mt. Ellery, is a broad band of metamorphic schist and gneiss, apparently metamorphosed Silurian. The central mass is a coarsely siliceous gneiss, the siliceous material standing out in weathered samples in wavy lines. On either side is a band of micaceous schist, and outward from this, nodular schist and phyllites. The difference between this mass and the metamorphism exhibited along the contact with the hornblendic granites, is that in the latter the adjoining slates or sandstones are only altered for a short distance from the contact—in the former, the alteration has taken place along a north and south line over a large area. The lithological character of these metamorphic rocks at once places them on the same stratigraphical horizon as the Omeo metamorphic schists. Here, as elsewhere (in the Australian Alps), the approach to the metamorphic schists is marked by frequent quartz segregations along the margin of the schistose area. At Mount Raymond are numerous quartz diorites and felstones, apparently associated with an intrusive mass of Devonian age *in situ*.

### Pliocene and Pleistocene.

The bouldery wash overlying the yellow miocene limestones and clays may be taken as a Pliocene. The deposition of these washes may be said to have taken place during an area of great rainfall. They are widely distributed along the coast regions of Gippsland, and are overlaid by the sandy coast deposits, which are probably Pleistocene and recent. The rich soils on the Snowy, at Orbost, and in the Bemm and Cann valleys, McCulloch Ranges, &c., are all younger formations.

### Auriferous Areas.

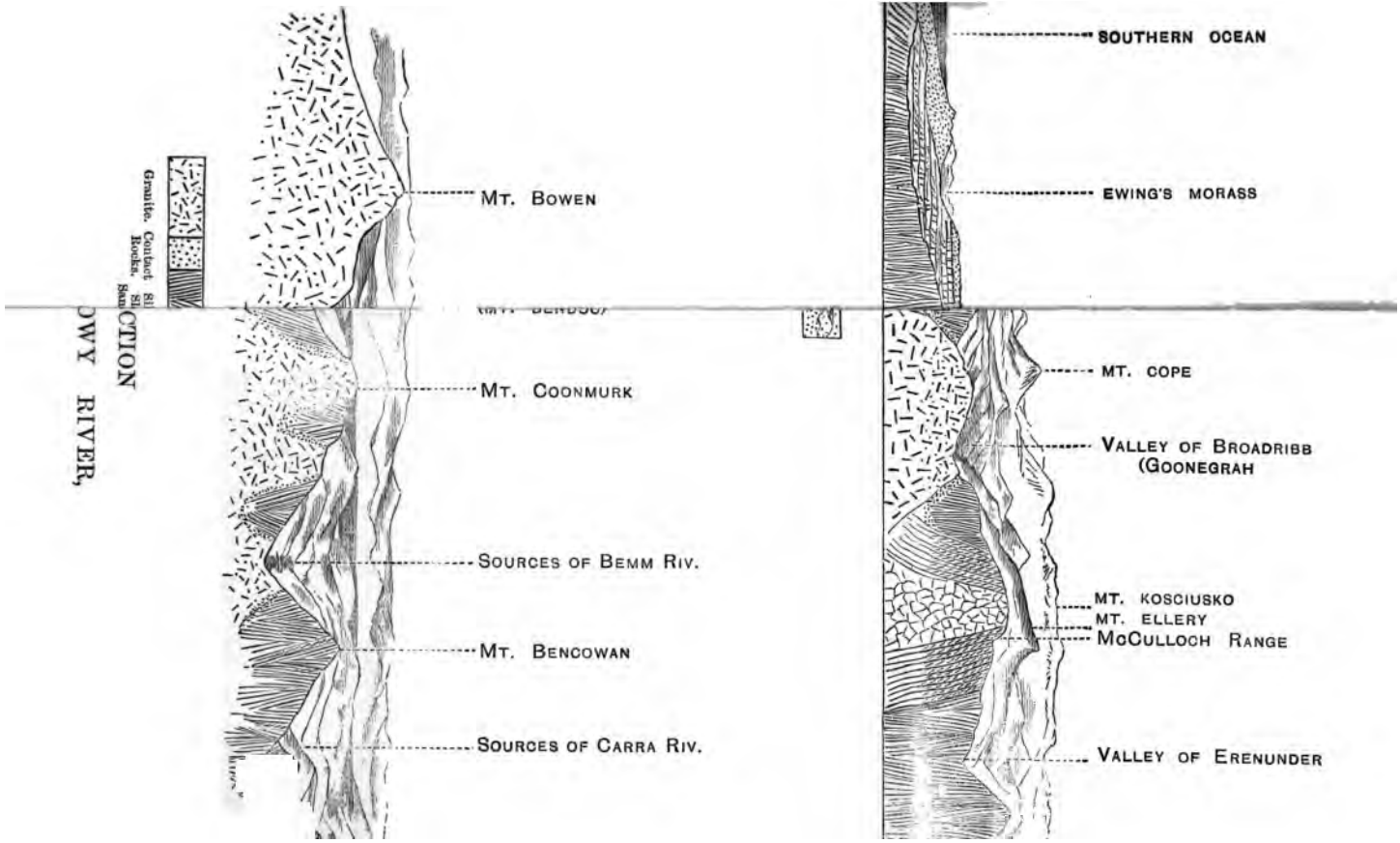
The only metal mined for within the area is gold, and principally in the Bendoc and Bonang districts north of the Coast Range. Here both quartz and alluvial workings occur. Although the prospecting parties have discovered many new auriferous localities on the south side of the Coast Range, no payable goldfields have yet been opened up. The upper portion of the Bemm, as at Combinebar Creek, contains alluvial gold in the creek flats; while recently, the prospectors, under control of Mr. Norman Whitelaw, leader of track-cutting parties, found rich specimens in the

McKenzie, a western tributary rising in the McCulloch Ranges.

In the upper tributaries of the Broadribb, alluvial gold has also been found towards the Coast Range. At both the McKenzie, Combinebar, and Upper Broadribb a legitimate field exists for quartz prospecting, the geological conditions being favourable in each place for such discoveries. It is on the north side of the Coast Range that payable alluvial and quartz gold is found.

The Queensborough, Back Creek, Little River, Bendoc, Delegate, and Bonang Rivers have all been worked successfully for alluvial gold, and at present reefs are being worked in the Bendoc and Bonang valleys. In the former, the Eclipse, Morning Star, and Come Love mines; and in the latter, the Rising Sun, Duke of Westminster, Crœsus, New Chum, Exhibition, and Young Australian. Most of these mines are in slate and sandstone formation, in some cases, as in the Rising Sun, heavily charged with pyrites and the joints coated with graphitic substance, rendering the ore refractory. Chlorination works, according to the Newbery-Vautin process, are being erected in the district. On the Snowy River are some cupreous lodes, which have not yet been mined. The original observations of that eminent geological observer, the Rev. W. B. Clarke, M.A., on the Bendoc auriferous areas, and his remarks as to future discoveries, have been amply borne out by recent mining developments. As one of the pioneers of geological research in Australia, his work stands, in the light of recent examinations, a model of patient and painstaking observation and sound geological reasoning. It must be borne in mind that Mr. Clarke did not follow the pick of the miner in these areas, but was in advance of such. I am confident the members of the Royal Society will pardon this digression from the subject matter of my paper, in the humble endeavour to do justice to the memory of one of Australia's scientific pioneers.

In a future paper, on the eastern portion of the county, I will endeavour to summarise the observations I have made on the physiography of the area, dealing at greater length with the meteorology, and also the mineralogy. The present article may serve as an introduction to the physiography of a little-known region of Victoria.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SOUTHERN OCEAN
EWING'S MORASS
MT. COPE
VALLEY OF BROADRIBB
(GOONEGRAH
MT. KOSCIUSKO
MT. ELLERY
McCULLOCH RANGE
VALLEY OF ERENUNDER

# NOTES FROM THE BIOLOGICAL LABORATORY OF THE UNIVERSITY OF MELBOURNE.

By W. Baldwin Spencer,

Professor of Biology in the University of Melbourne.

## (1) *On the presence of a Fluke in the Egg of a Fowl.*

I owe the specimens, upon examination of which this note is founded, to the kindness of Miss Stone, of St. Kilda, by whom they were found, and to whom my best thanks are due, for the very kind and untiring assistance which she rendered in searching for the animals in a great number of eggs. Miss Stone was successful in finding the living Trematode in three eggs and undoubted traces of the animal in numerous others obtained both in Melbourne and Ballarat, and she has thus succeeded in showing that the animal, which has been but comparatively rarely recorded before from the hen's egg, is probably not infrequently present in this position in Australia, and that its ova protected in their hard cases, are really often to be found in the hen's egg. The animal itself was first described and named by Rudolph as occurring in the bursa fabricia of different birds, and hence the adult on rare occasions apparently travels up the oviduct and reaching the part in which the "white of the egg" is formed, becomes entangled in this and carried down again, till finally the shell is secreted on the outside and the animal enclosed. The fluke was close to the ovum in the centre, and therefore must have travelled a considerable distance up the oviduct, or may have worked its way in towards the centre, after deposition of the egg. In the majority of cases there were present in the eggs what were undoubtedly remains of flukes in a more or less decomposed state. Their nature was rendered evident by the presence of the very characteristic ova of the flukes with the minute oval brown-coloured egg cases. How long these ova could remain alive, and whether when swallowed by some other animal they would develop, it is of course impossible to say, without experiment.

The adult fluke is at most not more than $\frac{1}{8}$-$\frac{1}{4}$in. in length. The alimentary canal has the usual form. The ovary is a racemose gland surrounding and opening into the part where the two ducts from the yelk-glands join and the uterus arises. The much-coiled uterus is full of ova with brown shell cases, and runs forward to open, not close to the male organs, but, as can be seen both in the whole animal and by means of a continuous series of transverse sections, anteriorly by the left side of the head sucker. The three adult animals examined agreed in this respect: in the whole animals the eggs could be traced forwards to the sucker, but this might of course have been due to their lying in a groove on the surface; sections showed that this was not so, but that the oviduct ran forward. The testes are two large oval bodies, one on each side of the ventral sucker. sucker. Their ducts unite and open in the usual position.

The excretory vesicle is well developed, and has strongly muscular walls. In sections the median canal can be traced as a single duct as far forwards as the ventral sucker.

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(2) *On the presence of a Pentastomum parasitic in the Lung of the Copper-head Snake (Hoplocephalus superbus).*

My attention was first drawn to this arthropod by my friend and pupil, Mr. Dombrain, who noticed its presence when cutting open a snake on King Island in November, 1887. Further searching showed me at once that the copper-head snakes of the island were infected by the parasite, which lives in their lungs. In one snake I counted no fewer than 129 specimens in the lung, and yet to all appearance this animal was perfectly healthy. When living they are of a bright red colour, due to the amount of blood sucked into the body from the lung of the snake.

The parasite lies with its head buried in the lung tissue and firmly attached by means of its four very definite hooks. The female, which is much the largest, measures when full-grown some 2 inches in length, and has from about 60-70 very distinct annulations on its body. The mouth is ventral and anterior, and apparently plugged by a somewhat triangular-shaped piece of tissue with chitinous edges. The anus

is posterior and terminal, and the generative opening placed ventrally some seven segments from the posterior end.

The male is much smaller and less frequently found than the female, from young forms of which it can easily be distinguished by the male genital opening, which is situated anteriorly on the ventral surface.

The body wall is composed of a very thick cuticle, through which open very numerous multicellular glands. Within the glandular layer, beneath the cuticle, lie the bands of circular and longitudinal muscles.

The alimentary canal consists of the œsophagus running upwards, lined with a definite cuticle, and opening on a papilla into the intestinal tube, which runs straight back dorsally to open at the terminal anus. The intestine is enclosed by the highly developed salivary (?) glands, which are formed of large nucleated cells, amongst which ramify numerous ducts. The ducts all unite on either side and run forwards into the head, the one of each side opening, apparently, on a slight papilla above the hooks.

In the female the ovary is single, and in the median line dorsally. Two oviducts unite at a point where are two bladder-like receptacula, and from here the uterus arises, which is much coiled and crowded with eggs, occupies a great part of the cœlom, and opens finally close to the posterior end.

The specimen resembles closely the form described by Leuckhart as *Pentastomum tænioides*, but is not quite similar to this apparently, and will be determined and described more fully subsequently.

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(3) *On the structure and presence of the Cestode Amphiptyches parasitic in Callorhynchus Antarcticus.*

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## (4) *Note on some Actinian Larvæ parasitic upon a Medusa from Port Phillip.*

By ARTHUR DENDY, M. Sc.

Demonstrator and Assistant Lecturer in Biology in the University of Melbourne.

[Read November 15, 1888.]

It has been known for a long time that the larval forms of certain species of Actinians are habitually parasitic upon Medusæ, thereby obtaining the advantages of free swimming without being obliged to possess locomotive organs of their own. I need enter into no details as to the observations of previous writers on this subject, as Professor Haddon* has already published a most valuable bibliography of larval Actiniæ parasitic on Medusæ.

According to this author, such parasitic larvæ have hitherto been found in North European seas, in the Mediterranean, on the coast of New England, and in the Southern Ocean. The object of the present brief note is to place on record the discovery of three parasitic Actinian larvæ on a Scyphomedusa from Port Phillip, which I had the good fortune to find on the occasion of the University Science Club's excursion to Cheltenham.

The Medusa upon which the specimens were found is a small monostomatous form about two inches in diameter. The bell is flattened, and the margin is notched into eight lobes, each subdivided into two halves by a deep indentation containing a tentaculocyst. The mouth is squarish, and at each corner is a rather large, somewhat flattened projection, with a much folded or crenated margin. These four projections are, of course, the oral arms. From the under surface of the Medusa, about half way between the oral arms and the margin, there arises a circle of very numerous, long, slender tentacles, arranged in eight horseshoe-shaped groups placed adradially. Each group contains about twenty-five tentacles, and the concavity of the horseshoe faces outwards. In the living animal the bell has a yellowish-brown tinge; the oral arms are of a warm sepia colour, sometimes with a

* Scientific Proceedings of the Royal Dublin Society, N. S., vol. 5, p. 473.

touch of crimson lake; and the long, slender tentacles are pale, dull pink. The species is one of the *Discomedusæ*, and belongs apparently to Hæckel's genus *Desmonema*.

I have given this brief description of the Medusa in the hope that local naturalists may be induced to search for the species and its interesting parasites.

The largest of the three Actinian larvæ, all of which were obtained from the same specimen, was attached by its own oral surface to one of the oral arms of the Medusa. The position of the two smaller ones is a little doubtful—they were only observed after the animal had been preserved in spirit.

I will describe the three parasites in order, commencing with the youngest:—

*(a)* The youngest example is approximately hemispherical in shape, and the diameter of the oral disk is about 3 mm. after preservation in spirit. The surface of the column is marked by only a few transverse and longitudinal furrows. No terminal pore was visible under the dissecting microscope, and it may be pretty confidently asserted that none exists. Twelve tentacles are already present as short, thick, translucent outgrowths around the margin of the disk. Within these, there is an inner circle of twelve cushion-like swellings, apparently produced by division of each tentacular outgrowth into an inner and an outer lobe—the outer lobe forming the true tentacle, and the inner lobe the cushion-like swelling. Some of the cushion-like swellings are not yet completely marked out. The mouth is in the centre of the oral disk, and furrows radiate towards it from between the tentacular lobes. Transverse sections demonstrate the important fact that twelve mesenteries are already present. They also show that the longitudinal furrows on the outer surface of the column correspond in position to the insertion of the mesenteries.

*(b)* The next specimen is rather more advanced in development. The general shape is still hemispherical, and the diameter of the disk has increased only slightly, to about 4 mm. The transverse and longitudinal furrows on the surface are more strongly developed, but this is probably in part, though not entirely, due to the action of the reagents employed. The twelve tentacles have elongated somewhat and become more conical, and the twelve cushion-like outgrowths on the disk inside them are very well formed.

*(c)* I was able to observe the largest specimen in the living condition. I have already stated that it was attached by its oral disk to an oral arm of the Medusa. Its general form was elongatedly conical, swelling out somewhat beneath the insertion of the tentacles, and narrowing greatly at the other end of the column; but doubtless the animal is capable of changing its shape to a considerable extent. The tentacles of the living animal were of a very dull, pale, bluish-grey colour. The column was very dull, reddish-brown, almost flesh-coloured, and showed longitudinal and transverse markings, probably corresponding to the grooves observed in spirit-preserved specimens. The conical tentacles are still twelve in number, but more elongated than in the earlier stages. Internally, at the base of each, is a saccular outgrowth corresponding to the similar cushion-like outgrowths noticed in the younger larvæ, but considerably larger. After preservation in spirit, the animal measured about 7·5 mm. in length and 6 mm. in diameter of the oral disk, excluding the tentacles.

I at first thought that my specimens were referable to the well known genus, *Halcampa,* and even to the species *H. clavus,* of which there is a good figure in Professor Hertwig's Report on the Challenger Actiniaria (Plate 3, Fig. 4). The presence of the remarkable outgrowths at the bases of the tentacles, however, shows that they cannot belong to that species, and even makes the generic identification doubtful. I do not think that these curious outgrowths have hitherto been observed in any other forms; according to Haddon's figures they are entirely wanting in the British *Halcampa chrysanthellum.* They may possibly serve as adhesive organs, by means of which the parasite is attached to its host.

Actiniæ are very difficult animals to preserve, and, although I took great care, I was not very successful in the preservation of my specimens. I therefore postpone giving figures and an account of the histology of the species, until better material is forthcoming. Meantime, it seemed to me worth while to call attention to the existence of these interesting parasites in Port Phillip, and to request other naturalists to search for them should the opportunity arise. It still remains to discover the adult Actinian of which they are the larval forms.

# MEETINGS OF THE ROYAL SOCIETY.

## 1888.

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[N.B.—The remarks and speeches in the discussions are taken down verbatim by a shorthand writer, and afterwards written out at length with a typewriter, for reference and reproduction, if required; and therefore, more is seldom given herein than an indication of their general drift. If any person should wish to refer to the verbatim report, he can apply to the Secretary to the Society, who will give him an opportunity of perusing and copying it, or if he resides at a distance, so much as he requires will, upon payment of the cost of reproducing it, be forwarded to his address.]

## ANNUAL MEETING.

*Thursday, March 8th.*

The President in the chair.

### Annual Report.

The Council of the Royal Society of Victoria presents to the Members of the Society the following Report for 1887. The following papers were read during the session, viz.—

On the 10th of March, 1887, a paper by the Rev. D. Macdonald, of Fate, New Hebrides, "On the Oceanic Languages, Semitic," was presented and read in abstract by Dr. Wild. Mr. H. T. Tisdall read "Notes on Fungi in Mines."

On account of the lamented death of Mr. S. W. McGowan, an old and valued member of the Society, the April meeting was suffered to lapse.

On the 12th of May, "Notes on the Occurrence of Glaciated Pebbles and Boulders in the so-called Mesozoic

Conglomerate of Victoria, contributed by Mr. E. J. Dunn, F.G.S., was read by Mr. Griffiths; and Mr. H. T. Tisdall read a second paper "On Fungi growing in Mines." Mr. A. H. S. Lucas, M.A., B.Sc., also read a paper "On the Production of Colour in Bird's Eggs."

On the 9th of June, Mr. H. S. Griffiths, F.R.G.S., read a paper "On the Geology of the Portland Promontory, Western Victoria."

On the 14th of July, Professor Andrew, M.A., read some "Notes on the Value of $J$ and the value of $g$;" and Mr. Ellery, F.R.S., F.R.A.S., gave an "Account of the proposed Photographic Charting of the Heavens."

On the 11th of August, Professor W. C. Kernot, M.A., C.E., read some "Remarks on the Early History of the Brennan Torpedo," and Mr. C. R. Blackett, F.C.S., read "A Note on some determinations of Chlorine in the Water of the Yarra." Mr. A. W. Howitt, F.R.G.S., then read a paper "On certain Metamorphic and Plutonic Rocks at Omeo."

On the 8th of September, Baron Von Mueller, K.C.M.G., F.R.S., &c., presented "Descriptive Notes on a Victorian *Halorugis* and a *Pluchea*," with some general considerations on systematic phytographic arrangements. Professor Kernot also described and exhibited some Models of Engine Governors and Dynamometers.

On the 13th of October, a paper was presented and read by D. McAlpine, Esq., entitled "Observations on the Movements of Detached Gills, Mantle Lobes, Labials Palps, and Foot, in Bivalve Molluscs."

On the 10th of November, Professor W. Baldwin Spencer's paper on "The Structure and Classificatory Position of *Megascolides australis*," was read in abstract by Mr. A. H. S. Lucas, in the absence of the author, and Mr. G. R. B. Steane read a paper "On Rainfall and Flood Discharge." Dr. Jamieson also read an account of "Some Experiments on the range of Action of the Digestive Ferments."

On the 9th of December, at the Annual Conversazione, the President read his Annual Address, and Professor Spencer described the *Megascolides australis*; and on the 15th of December, Baron von Mueller's description of some Papuan Plants was presented, and the President read a

paper contributed by Mr. T. Wakelin, B.A., of Greytown, New Zealand, on "The Production of the Tides, Mechanically Considered."

Your Council has departed from the usual custom, by holding the Conversazione at the end of the session in December, and judging by the great success of the meeting, the change may be regarded as an improvement. The principal objects in doing so were that the proceedings of the whole year could thus be noticed and reviewed by the President in his Address, and that the year's Transactions might be completely published in the annual volume during the recess, instead of combining in the same volume the Annual Report and proceedings of one year with the transactions of the preceding year. It may probably be found better another year that the Monthly Meeting in December should precede the Conversazione instead of being held the following week.

Your Council has to congratulate the Society upon one important step in the right direction having been made during the past year. The Microscopical Society of Melbourne has found it to its advantage to combine with the Royal Society and to form Section D, as provided for in the Laws of this Society. This brought an accession of thirty members to the Royal Society. Eleven other members and three honorary members of the Microscopical Society were already members of the Royal Society, and did not require to be elected. It is to be hoped that other societies will follow the example of the late Microscopical Society, and illustrate the truth of the old adage that union is strength.

The following members and associates have been elected during the year:—Messrs. A. H. Jackson, B.Sc., F.C.S.; J. B. Lewis; J. J. Wild, Ph.D., F.R.G.S.; and W. H. Irvine, on the 10th of March. Professor D. O. Masson, as a member; Mr. C. H. Richards, as a country member; and Messrs. Pietro Baracchi, James Blackburn, Rev. A. W. Cresswell, Mr. W. S. Dawson, Dr. Thomas Porter, and Mr. G. A. M. Pringle, as associates, on the 9th of June. Professor W. Baldwin Spencer was duly elected a member on the 14th of July, together with the following members of the late Microscopical Society:—Messrs. M. J. Allan, W. W. Allan, W. H. Archer, F.L.S., F.I.A., &c.; F. H. Baker, W. M. Bale, Wm. Ball, F. Barnard, W. R. Bennetts, Jun.,; W. W.

## Dr. *The Hon. Treasurer in Account with the Royal Society of Victoria.* Cr.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| To Balance from 28th Feb., 1887, as per last Balance-sheet | | | | | | £545 | 19 | 6 | By Printing and Stationery | | £233 | 3 | 0 |
| ,, Government Grant— | | | | | | | | | ,, Architect's Charges | | 13 | 4 | 0 |
| Balance of Vote for 1886-87 | | £50 | 0 | 0 | | | | | ,, Books | | 1 | 16 | 0 |
| Portion of do. 1887-88 | | 150 | 0 | 0 | | | | | ,, Purchase of Early Transactions | | 9 | 0 | 0 |
| | | | | | 200 | 0 | 0 | | ,, Binding | | 1 | 1 | 0 |
| ,, Entrance Fees (5) | | | | | 10 | 10 | 0 | | ,, Freight and Charges | | 2 | 16 | 9 |
| ,, Subscriptions— | | | | | | | | | ,, Conversazione, &c. | | 32 | 10 | 9 |
| 70 Ordinary | | 147 | 0 | 0 | | | | | ,, Expenses of Port Phillip Biological Survey | | 44 | 11 | 6 |
| 26 Country | | 27 | 6 | 0 | | | | | ,, Hire of Room for Antarctic Committee | | 1 | 11 | 6 |
| 44 Associated | | 46 | 4 | 0 | | | | | ,, Rates | | 5 | 10 | 0 |
| 2 Do. (Half-year) | | 1 | 1 | 0 | | | | | ,, Gas and Fuel | | 7 | 16 | 2 |
| Arrears | | 34 | 13 | 0 | | | | | ,, Clerical Assistance | | 100 | 0 | 0 |
| | | | | | 256 | 4 | 0 | | ,, Records of Proceedings | | 21 | 0 | 0 |
| ,, Rent and Gas | | | | | 13 | 0 | 0 | | ,, Hall-keeper | | 6 | 0 | 0 |
| ,, Sale of Transactions | | | | | 1 | 1 | 3 | | ,, Collector | | 34 | 6 | 11 |
| ,, Interest | | | | | 25 | 12 | 6 | | ,, Insurance | | 3 | 10 | 0 |
| | | | | | | | | | ,, Postage | | 34 | 4 | 5 |
| | | | | | | | | | ,, Outstanding Debenture (1) and Interest | | 9 | 4 | 0 |
| | | | | | | | | | ,, Petty Cash, Advertising, &c. | | 11 | 0 | 3 |
| | | | | | | | | | ,, Transferred to Publishing and Research Fund | | 300 | 0 | 0 |
| | | | | | | | | | ,, Balance in Bank, 1st March, 1888 | | 179 | 19 | 10 |
| | | | | | £1052 | 7 | 3 | | | | £1052 | 7 | 3 |

Compared with the Vouchers and Bank Pass-book and Cash-book, and found correct,

H. MOORS,
HON. TREASURER.

27*th February*, 1888.

(Signed) JAMES E. GILBERT, } AUDITORS.
ROBERT E. JOSEPH, }

## Dr. PUBLISHING AND RESEARCH FUND. Cr.

| | | | |
|---|---|---|---|
| Transferred from General Fund .. .. .. | £300 0 0 | By Balance in Bank .. .. .. .. .. | £300 0 0 |

*The Hon. Treasurer in Account with the Fund in Aid of the Widow of the late Dr. Davy.*

| | | | |
|---|---|---|---|
| To Balance in Bank .. .. .. .. .. | £100 0 0 | By Paid to Mrs. Davy .. .. .. .. | £106 0 0 |
| „ Interest .. .. .. .. .. .. | 6 0 0 | | |
| | £106 0 0 | | £106 0 0 |

Examined and found correct,

H. MOORS,
Hon. Treasurer.

27*th February*, 1888.

JAMES E. GILBERT,
ROBERT E. JOSEPH, } Auditors.

Dr. STATEMENT OF LIABILITES AND ASSETS. Cr.

| LIABILITIES. | | ASSETS. | | |
|---|---|---|---|---|
| To Debentures (2) outstanding .. .. .. £10 0 0 | | By Outstanding Subscriptions (estimated) .. £40 0 0 | | |
| ,, Interest unclaimed .. .. .. .. 8 8 0 | | ,, Rents due (estimated) .. .. .. .. 20 0 0 | | |
| ,, Estimated Outstanding Liabilities .. .. 50 0 0 | | ,, Hall, Library, and Furniture .. .. .. 3700 0 0 | | |
| ,, Balance .. .. .. .. .. .. 4171 11 10 | | ,, Balance in Bank, Publishing Fund £300 0 0 | | |
| | | General Account 179 19 10 | | |
| | | | 479 19 10 | |
| | £4239 19 10 | | | £4239 19 10 |

1st *March*, 1888.

H. MOORS,
*Hon. Treasurer.*

On the motion of the President, seconded by Mr. White, the Annual Report, as printed and circulated, and amended as under, was received and adopted. It was agreed that a reference to the death of Professor Balfour Stewart should be inserted immediately after the obituary paragraph.

It was also agreed that the name of Mr. A. H. S. Lucas, which had been accidentally omitted from the list of members of the Committee for the Biological Exploration of Port Phillip, should be inserted.

After some discussion with regard to the publication of a catalogue of books in the library, the office-bearers for the coming year were elected as follows :—

*President,* Professor Kernot, M.A., C.E.

*Vice-Presidents,* { E. J. White, Esq., F.R.A.S.
J. Cosmo Newbery, Esq., C.M.G., B.Sc.

*Hon. Treasurer,* James Jamieson, Esq., M.D.

*Hon. Librarian,* J. E. Neild, Esq., M.D.

*Hon. Secretaries,* { H. K. Rusden, Esq.
F. Barnard, Esq.

*Members of Council,* R. L. J. Ellery, Esq., F.R.S., F.R.A.S.; G. S. Griffiths, Esq., F.G.S.; Prof. Orme Masson, M.A., D.Sc.; H. Moors, Esq.; J. T. Rudall, Esq., F.R.C.S.; Prof. W. Baldwin Spencer, B.A.

The meeting then resolved itself into an ordinary meeting, and the minutes of the last ordinary meeting were read and confirmed.

Mr. James Wilson was elected as an associate.

The PRESIDENT read a letter received from Professor Liversidge in reference to the Australasian Association for the Advancement of Science. The letter was in reply to one addressed by Mr. Rusden to Professor Liversidge regarding the proposal made by the Exhibition Commissioners, that a gathering of scientists should be held in Melbourne some time within the period set apart for the Exhibition. The President added that it had already been decided to hold the first meeting of the Association in Sydney, in August or September, and it remained to be seen how the desire of the Exhibition Commissioners could be met.

Mr. JENNINGS' paper on "Irrigation" was postponed, in the absence of the author from the colony.

Dr. WIGG read a paper on "The Proposed Introduction of New Diseases into Australia."

The PRESIDENT said it would be agreed that this question was one of great importance, indeed of urgency at the present moment. The steamer on which M. Pasteur's emissaries had embarked was close at hand, and unless some step were taken the experiment would be tried. Of course it was possible that nothing would come of it, that it would hurt no one, not even the rabbit. It might affect the rabbit and no one else. Yet there was reasonable probability, as Dr. Wigg had stated, that it would do a great deal of harm, in any event it was a step that should not be taken blindly.

Mr. MARKS was glad to be able to say that Dr. Wigg in his paper mentioned a great many points on which he (Mr. Marks) had laid great stress, in a letter written to the Chief Secretary. If the influence possessed by the Royal Society were brought to bear on the Government it might be the means of preventing the introduction and extension of cholera microbes in the colony.

Dr. JAMIESON said there could be no doubt of the importance of the question Dr. Wigg had dealt with that evening. Dr. Wigg had been good enough, at comparatively short notice, to undertake to bring the matter before the Society. The fact that the paper was not on the notice paper might have prevented some from trying to make themselves better acquainted with the subject. However, it was but fair that the matter should be brought before this, the leading Society of the colony, as the Society was known to have weight with the Government. He had been endeavouring, with such opportunities as he had had, to make himself acquainted with the present state of knowledge of this question. On some of the points Dr. Wigg had referred to, he had been able to collect some important information, which might be useful in connection with this discussion. Firstly, with reference to the nature of the disease. As far as he understood it, it was not cholera at all. He understood that it got its name—fowl cholera—from the fact that it occurred with great virulence and spread violently in France at a time when the genuine cholera was very prevalent. It had not the symptoms of cholera, and in other countries than France it was not called cholera. In Germany it was called "fowl typhoid," or "bird typhoid." Dr. Wigg referred to the fact, as he

said, that information had been withheld. He did not know how far it was proper to say that it was withheld, deliberately withheld, for some purpose; but certainly, they had not got specific information as to the spread of the disease from fowls to other birds. In the year 1883 a report was made by a well-known veterinarian, in a fowl-fancier's journal, published in Dresden, as to an examination which had been made of the bodies of a large number of birds that had died. His report was, that out of 365 birds examined after death, no fewer than 122 had died of this fowl typhoid. Included in the number of birds that had died of this disease were 79 fowls, 17 pigeons, 9 geese, 8 turkeys, 5 ducks, 3 ordinary pheasants, and a foreign pheasant. Considering that only domesticated or semi-domesticated birds were likely to be found dying of disease, and have their bodies examined, it might be taken for granted, judging from the large variety of birds that had been affected, as stated, that the disease would spread through all kinds of birds. It had not been proved that it affected any special kind. In so far as birds were known, there was apparent evidence that it would spread to any kind. It could not be limited to fowls and rabbits. If it once got into this community it might possibly sweep over the country, and, if not exterminate, gradually diminish the number of both tame and wild birds. That was an important point, and might be taken as supplying evidence that Dr. Wigg and himself thought should rightly and properly have been supplied. There was another important matter to be considered, and that was the relation of this disease to diseases in other animals. He found that in the year 1878 a disease was very prevalent in Germany amongst game animals, particularly deer. A very large number died from some not well understood epidemic disease. An inquiry into the nature of that disease was conducted by a well-known veterinarian. His first suspicion was that it was anthrax. He did find, correctly or not, that there was abundance of room for a difference of opinion. He found an organism that he considered was the cause of the disease. If not identical with the organism found in fowl cholera and the disease affecting rabbits, yet it bore a very close resemblance to it. The disease in fowls, the disease affecting rabbits, and one called "swine disease," all bore a great similarity as regards the organisms present in all of.

them. More recently the question had been taken up again. He held in his hand a very full summary of papers published on the subject in Berlin, at the end of 1886, by a well-known authority on this particular question. His inquiry was as to the relation probably existing between this disease and others. His general conclusion was, that the swine sickness, probably also the rabbit and fowl cholera, were only various manifestations of a disease which he would describe in a general way by one name. Therefore, though it might be said that M. Pasteur is a great discoverer, anxious to gain further fame, yet there was reason to suppose that some risk would attend the introduction by him of the fowl cholera. A serious responsibility would be incurred by the Government of this or any other colony were they, without very careful inquiry, to allow experiments to be made on this continent in the rash way proposed. However, it was somewhat doubtful, supposing the disease were introduced, whether or not it would serve the purpose of destroying the rabbits. Dr. Wigg had clearly pointed out that the experiment in France was made under conditions different to those which were to be met with here. The result of that experiment was simply that a certain number of rabbits had been poisoned and nothing more. It had been shown that the disease would be spread over large areas by the ordinary means of contagion. No satisfactory proof had been given that it would serve the purpose intended, and in view of that fact, and of the supposition that the disease might spread to other animals and birds, the matter was one which should be seriously considered. He did not agree with many who, in speaking and writing on the subject, had stated that the disease would acquire here new features, of special virulence for instance. It was very true, as Dr. Wigg had stated, that a great many deaths from measles occurred in Fiji, but apart from the fact that measles were then introduced for the first time, it was known that the natives deliberately refused to be treated, and exposed themselves to dangers such as would cause disease to be fatal in any country. Still it must be borne in mind that when scarlet fever came into this country from Europe, and when its nature was first discussed here in 1854 and 1855 it was quite a mild disease. It did not rage then at all. The same held good of measles, which always was an extraordinary mild disease in Australia.

So far as his experience went, he was not aware that any disease introduced into Australia had shown more virulent properties here than it had in other parts of the world. He did not think the fowl cholera would acquire new properties here—would become extraordinarily virulent, or would be the cause of effects unknown elsewhere. It was now recognised that fowl cholera was making great havoc amongst domestic fowls and birds in France and Germany, and probably in other countries of Europe, and that in all likelihood it would spread to a considerable extent here, though it might happen, on account of our large areas, that it would not spread so readily as it did in the more crowded parts of Europe, where fowls were met with at every few paces all over the country. He did not know of any evidence showing that the disease would spread to human beings. It had been said that there had been ample opportunities for such a power if it existed to have been developed in the old countries, and it was not at all likely that such a property would be developed by the mere introduction of the disease into Australia.

Mr. C. R. BLACKETT thought that Dr. Wigg's paper was timely. It would be better to bear the ills they had, than fly to others they knew not of. It should be known that M. Pasteur had saved millions to France. He had benefitted the wine culture by investigating the disease in vines, and had discovered the cause of disease in silk worms. Though he had gained the respect and even the confidence of scientific men, still they were not to accept without question all that he proposed. Dr. Jamieson had alluded to the fact that various diseases in certain animals were modifications of the same thing, but the investigations of the ablest microscopists seemed to indicate that they were quite distinct. He agreed with Dr. Wigg and Dr. Jamieson that the Government were bound to take steps to prevent the introduction into the colony of the form of disease proposed to be introduced by M. Pasteur, except under the most stringent conditions. It might be advisable to quarantine M. Pasteur's emissaries at Flinders Island. If the fowl cholera would kill the rabbit, and could be propagated amongst rabbits, and if its origin was with the winged tribes generally, would it not go back to them? That appeared to be the logical conclusion. He thought M. Pasteur had not thoroughly recognised the enormous distances in this country, nor that Australia was sparsely

populated with people, and that the rabbits were scattered over wild and scarcely-populated districts. While the microbes might kill rabbits in one burrow, how could the disease be propagated for long distances? Certain rabbits would escape, and their fecundity was well known. Those were matters for future consideration, but it was quite right that a warning note should be sounded.

Mr. BOSISTO thought the Society was greatly indebted to Dr. Wigg for bringing the matter forward, inasmuch as the results of the introduction of the disease might be very serious. Birds and animals might be affected by the disease. He would refer to Pasteur's experiments in the 19 acres already alluded to. It was well known that if a field containing a large number of rabbits were walled in the rabbits could be destroyed by means other than that adopted by Pasteur, and just as rapidly as he destroyed them. He (Mr. Bosisto) was not speaking ignorantly on this subject, as he himself had had to deal with 11½ square miles of Mallee country, on which he had seen tens of thousands of rabbits—not altogether on that block, but in and around it. By paying attention to the matter of getting rid of them he had so far succeeded, that instead of their now being thousands of rabbits on his land he did not think that 500 could be found. Endeavours should now be made to induce the owners of land throughout Australia to undertake one uniform and regular system of destruction. There were peculiar circumstances connected with M. Pasteur's experiments in the 19-acre block. Firstly, the rabbits had eaten up the whole of the vegetation, so that when the clover, over which the liquid containing the microbes had been spread, was placed in the enclosure, they ate it greedily, and death resulted in a large number of cases. He (Mr. Bosisto) and others in Victoria had, in the dry seasons when the ground was bare, adopted somewhat similar means, with equally good results as regards the rabbits on this ground. In summer, when there was plenty of green grass which the rabbits liked to nip from the living plant, the only thing they found could be done was to place bi-sulphide of carbon in the warrens; but when the ground was as bare as it was for M. Pasteur's experiment then they killed them by thousands. Little heaps of as much chaff as could be got into a tumbler were placed near the warrens, and upon those heaps were poured a weak solution of arsenic. Simple as this remedy seemed,

it did what was desired. Thousands and tens of thousands of rabbits were killed after eating the chaff, which they did ravenously. They could get nothing else. On Madame Pomeroy's 19-acre block they could get nothing more than what was given them by M. Pasteur. His (Mr. Bosisto's) candid opinion was that we had the remedy in our own hands. We wanted neither microbes nor any other dangerous material imported into this country. He made these observations to show that while we possessed an animal that bred rapidly, yet we possessed a remedy, and did not require to introduce others. He hoped the steps would be taken to carry out Mr. Blackett's suggestion of quarantining. If the imported disease destroyed the birds, a great evil would be done to the community, as locusts, grasshoppers, and other insects would increase. His land, to which he had referred, was now looking green and beautiful, the rabbits having been greatly lessened in numbers by the adoption of the remedy spoken of. One day the locusts swept across the whole 600-acre block, and demolished every particle of green thing there, and still went on. Yet crows and other birds followed and feasted on the locusts. The poisoned chaff which the rabbits ate was spread so carefully, that very few birds were killed by it. The rabbits, however, died in thousands.

Dr. RUDALL.—If such a disease as fowl cholera were introduced he did not think it was in the power of any human being to say where it would stop. In old countries it could be estimated, but not in a country like Australia. Dr. Wigg had instanced the occurrence of measles in Fiji, and stated that it was a new disease there, and had proved fatal in a large number of cases. Dr. Jamieson seemed to think that the disease had proved fatal in so many cases because of the great carelessness shown on the part of those who were attacked. He did not think that was a full explanation of the occurrence. Many years ago measles were introduced into the Faroe Islands. That disease had not been known there in the memory of man, yet it was remarkably fatal, and it did seem therefore that when disease fell upon virgin soil it was very likely to be much more fatal than among communities who had been habituated to it.

Mr. G. S. GRIFFITHS moved, "That having heard Dr. Wigg's notes on this subject, and the remarks made by the other gentlemen present, the Royal Society

respectfully advises the Australian Governments to refuse their permission to any person to introduce any form of disease for the purpose of checking the rabbit plague, until the whole question has been fully considered."

Mr. JACKSON seconded the motion. Dr. Wigg had done a great service to the Society in calling attention to the subject. He gathered from the remarks that had been made, that it was not yet certain whether or not this disease would be communicated from one set of rabbits to another set. If it were not so communicable, then its value as a means of ridding the country of the pest would be nil. If, on the other hand, it were valuable for the purpose of ridding the country of the pest, by being easily communicable, it would have the disadvantage of carrying off a great proportion of the number of domestic fowls and other birds. It seemed to him, that the people here were on the horns of a dilemma. From either point of view, it was desirable to prevent the importation of the disease into the colony.

The PRESIDENT said that before the motion was put, he would like to say a word or two. He did not speak as a medical man, nor as a biologist. He was an engineer, and, he trusted, a scientific one. It had been said, that M. Pasteur's investigations of the vine disease and the silk worm were models of scientific investigation. On the strength of that, it might be assumed that his experiments with the chicken cholera had been equally exhaustive and minute. If that were so, it was strange that no information of such an exact investigation was to be met with. An experiment, unless it were properly arranged and tried, would be simply misleading. There had appeared in *The Argus* a column or more containing the extraordinary story about the rabbits in Madame Pomeroy's vineyard. He was greatly astonished that such unscientific proceedings should be put forward as a conclusive experiment. Suppose instead that a solitary infected rabbit had been placed in that 19-acre paddock, and that then in the course of a week the rabbits had died the inference would have been different. The result obtained by M. Pasteur was in no way different from that arrived at by Mr. Bosisto simply by the use of arsenic. One of the first questions that occurred to him was, could not the same result have been obtained with any ordinary poison, and if chicken cholera was not different to ordinary poisons that were

used, what was the need of bringing it here at all? Mr. Bosisto's evidence regarding the arsenic was most important. Why go to an unknown and possibly very dangerous agent, when the desired object could be effected by a cheap and possibly safe one?

The motion was put and carried unanimously.

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*Thursday, April 12th.*

The President in the Chair.

## THE AUSTRALASIAN ASSOCIATION.

The PRESIDENT said that a communication had been received from Professor Liversidge intimating that the Australasian Association for the Advancement of Science, having been duly established, with the concurrence and support of almost the whole of the scientific and learned societies throughout the colonies, the first general meeting of the Association would be held in Sydney, on the 4th September next, and continue for several days following. The Association, it would be remembered, arose out of a proposal made by Professor Liversidge in November 1886, on which occasion a meeting was held at the Royal Society's House in Sydney, under the presidency of Mr. Russell, and at which a large number of the learned, scientific, and professional societies of New South Wales, New Zealand, South Australia, Tasmania and Victoria were represented. At that meeting it was resolved unanimously that the Association should be formed on the lines of the British Association, and that the first meeting should take place in the Centennial year, 1888. The time was approaching for the holding of that meeting, and it was hoped that the members of the Royal Society of Victoria would not be slow in supporting so desirable a movement. The Association did not propose to trench upon the operations of or interfere with any existing scientific body. Its meetings were intended to be annual, as were those of the British Association. The first meeting would be held, as already arranged, in Sydney, and the second meeting, it was almost certain, would be held in Melbourne. Those annual meetings on the lines of the British Association would unquestionably do great good. They would bring scientific men together, and would enable those who had been working on different lines to come into personal

communication. At present, the scientists of Melbourne met the scientists of Melbourne, but had not the opportunity of meeting those of Australasia. The meetings of the Association would afford that opportunity. An annual volume such as was published by the British Association would be published. The great facilities that now existed for travelling between the principal Australian colonies would promote the prosperity of the Association; in fact, he might say, they would render possible the existence of such an Association. In connection with the meetings it was proposed to have excursions to places of interest, especially of scientific interest. Therefore the meetings would not only be interesting from a scientific point of view, but would afford relaxation, health, and pleasure. The subscription was £1 1s. per annum. It was intended to pay the incidental expenses of holding meetings, printing, sending out notices and so forth, and also the expense of publishing the Transactions. Each subscriber would receive a copy of the annual volume, and, in fact, of all publications of the Association. That the movement should be warmly supported was highly desirable. It was a step in the direction of federation and of harmonious co-operation, and could not fail to be productive of good in a multitude of ways. Their Sydney friends had the right to claim that the first meeting should be held in Sydney, as New South Wales was the oldest colony, and this was the Centennial year. The movement had been fostered, and the preliminaries arranged by the scientific gentlemen in Sydney, and all that Victorians had to do was to support it as earnestly and warmly as they could. There would be a series of sections within the Association similar to those in the British Association, so that persons studying different branches of science would find a congenial sphere in which to work. The sections were ten in number. He trusted that members would not overlook this very important movement, nor allow their Sydney friends to accuse them of lukewarmness in the matter. If they paid their subscriptions, attended the meeting in Sydney in considerable numbers, and contributed papers, they might rest assured that their Sydney friends would be greatly encouraged, and that the year after they would have a large and successful meeting in Melbourne.

The PRESIDENT then read the Annual Report of the Hon. Librarian, Dr. Neild.

Mr. RUSDEN read a paper by Robert Abbott, Esq., C.E., on "The Maintenance of Energy."

The PRESIDENT remarked that there was one point in the paper with which he was not quite satisfied, viz., the mode in which the length of time necessary for the production of the features of the earth's surface and its flora and fauna was arrived at by the biologists and geologists. The physicists had certain definite data to go upon, but on the biological side he failed to see where were the data for such definite conclusions. Mr. Abbott did not seem to have given them a great deal that was new on the subject dealt with in the paper.

Mr. FRAZER thought the title of the paper incorrect; that there was nothing in it to show how energy was maintained.

Professor MASSON said that Mr. Abbott asked them to follow him in assumptions, as, for example, that the primordial matter was below possibly the absolute zero of temperature—that it was without molecular motion—which required much more justification than he had given for them.

The PRESIDENT read a paper by Mr. Newton C. Jennings, on "Irrigation and Water Supply in the Australian Colonies."

Mr. FENTON did not see anything in the paper open to discussion, and remarked on the peculiar fluctuation in the rainfall of the colony.

Mr. F. A. CAMPBELL thought that everything in the paper might be taken as a matter of course. Though the average rainfall of the colony was ample for all wants, yet in certain parts of the colony where irrigation was most necessary, it was small. Search should be made to ascertain where water existed below the surface, so that it might be tapped.

The PRESIDENT remarked that Mr. Jennings could hardly be aware of how much work had already been done. All the more important streams in the northern watershed of the colony were being gauged very carefully, and the results recorded and printed. He did not agree with Mr. Jennings' statement that there was no question as to the right of Government to intercept the rainfall on its own land.

*Thursday, May 10th.*

The President in the chair.

Messrs. Wm. Bage, W. H. Nimmo, S. C. Candler, and Arthur Dendy, M.Sc., F.L.S., were nominated as members.

The HON. LIBRARIAN announced that since the last meeting, thirty-four scientific publications had been added to the library.

The PRESIDENT announced that Mr. Lucas had resigned his position as Member of Council, owing to pressure of work. Mr. White proposed, and Professor Spencer seconded, a motion that Mr. Topp be elected to the vacant position. The motion was carried.

Mr. RUSDEN read a paper by Mr. T. Wakelin, B.A., of New Zealand, on "An experiment to show how the earth is made to gravitate towards the Sun." Mr. White remarked that Mr. Wakelin wished to go beyond the theory of gravitation.

Mr. RUSDEN read a paper by the same author, on "The Dynamical Equivalent of a Pressure."

The PRESIDENT said he thought the author failed to appreciate the true conditions of such an experiment. The results of his experiment would vary in accordance with the way in which his apparatus was made.

On the motion of Professor Spencer, seconded by Mr. Griffiths, the standing orders were suspended to allow of Mr. Dendy reading his paper on "The Anatomy of an Arenaceous Polyzoon."

The PRESIDENT congratulated Mr. Dendy on having so soon after his arrival in the colony, made an original contribution to biological science.

Mr. BRACEBRIDGE WILSON had for long known the animal without suspecting its polyzoon nature.

Professor SPENCER referred to the important work carried on by Mr. Wilson in his biological explorations in the waters of Port Phillip, in which he had discovered many new and remarkable forms.

Professor SPENCER read a paper on "The Presence of a Fluke in the Egg of the Common Fowl."

Mr. LUCAS did not quite understand how the adult fluke got into the egg.

Mr. FENTON remarked that the presence of the fluke in eggs was entirely unsuspected by the general public, and the President suggested that it would be interesting to know to what extent, if at all, it was dangerous as far as human beings were concerned.

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*Thursday, June 14th.*

Mr. White, Vice-President, in the chair.

Mr. C. A. Topp, M.A., LL.B., F.L.S., was elected as a member of the Council.

Messrs. William Bage, Samuel C. Candler, Arthur Dendy, M.Sc., F.L.S., and William H. Nimmo were elected as members of the Society.

Professor SPENCER read a note "On the presence of a Pentastomum parasitic in the Lung of Hoplocephalus superbus."

A short discussion ensued.

Mr. ARTHUR DENDY submitted a "List of all the Species of Sponges described by H. J. Carter, Esq., F.R.S., together with a number of his more important references to the species of other authors."

Mr. ELLERY said he desired to mark his sense of the very great importance of the work to which Mr. Dendy had devoted himself.

Professor SPENCER then read a note "On the Presence of a Rare Cestode (Amphiptyches) in Callorynchus antarcticus."

Dr. NEILD reported that since the last meeting 69 scientific publications had been added to the Society.

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*Thursday, July 12th.*

The President in the chair.

R. A. BASTOW, Esq., F.L.S., was elected a member of the Society.

The PRESIDENT introduced Sir James Hector, Chancellor of the University of New Zealand, and representative of the latter colony to the Centennial International Exhibition.

Sir JAMES HECTOR thanked the members for the welcome accorded to him.

A letter was received from Dr. McInerney stating that at a meeting of the Australian Natives' Association it had been decided that he should deliver a lecture upon Seals, and inviting members of the Royal Society to attend and speak upon the question, which had a connection with the subject of antartic exploration.

Mr. RUSDEN then read a paper for T. S. Hall, Esq., M.A., "On Two New Fossil Sponges from Sandhurst."

Sir JAMES HECTOR inquired if any researches had been carried on in the neighbourhood of Schnapper Point, since in beds similar to these in New Zealand he had discovered a beautiful specimen of Euplectella.

Mr. DENDY stated that this was the first sponge recorded in Australia from palæozoic formations.

The PRESIDENT congratulated Mr. Hall, as a student of the Melbourne University, on his interesting discovery.

Mr. DENDY then read a paper entitled "Preliminary Account of the Anatomy and Development of Stelospongus flabelliformis."

After some discussion, in which Sir James Hector, Professor Spencer, and Mr. Lucas took part, the President gave a description of the new Hawkesbury Railway Bridge.

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*Thursday, September 13th.*

The President in the chair.

Messrs. James Ivey, Henry Shaw, John Cockburn, and A. W. Dixie were nominated as members.

The following were elected as members:—Dr. Alexander Morrison, Newton E. Jennings, Esq., J. M. Coane, Esq.

Dr. NEILD stated that the sub-librarian was working very hard in getting the library into manageable shape, and it was hoped that in the course of a few weeks a catalogue would be ready.

The PRESIDENT gave an outline of the proceedings of the Australasian Association for the Advancement of Science held in Sydney.

Professor ORME MASSON read a paper by himself and Mr. Kirkland on "Polyhaloid Salts of Organic Bases."

After some discussion, in which Messrs. Blackett, A. Sutherland, Marks, and Lucas took part, Mr. Ellery exhibited and described a new Watkin's Aneroid.

Mr. ELLERY also exhibited and described a new instrument he had devised for calibrating a particular form of pressure-gauge tester, known as the "Admiralty P.G. Tester."

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*Thursday, October 11th.*

The President in the chair.

Messrs. James Ivey, Henry Shaw, A. W. Dixie, and John Cockburn, were elected as members.

The HON. LIBRARIAN reported the addition of 75 new publications to the library, and that the Catalogue was nearly complete.

The PRESIDENT drew the attention of the Society to the presence in the Exhibition of the first locomotive which ever ran. It was made by Murdoch and Fried, at Redruth in Cornwall. The President gave an outline of the history of the steam boat, and invited the Rev. Dr. Fraser to make a few remarks upon a model of the first steam boat built by Symington, and now exhibited to the Society.

After an interesting account by the Rev. Dr. Fraser of Symington's work,

Mr. F. A. CAMPBELL read a paper on "The Active Volcano of Tanna, New Hebrides."

A discussion ensued, in which the President, the Rev. D. Macdonald, and Professor Spencer took part.

The PRESIDENT said that before closing he must refer to the great loss that the scientific community in Melbourne had sustained in the death of Professor Andrew. He had been for five or six years Professor of Natural Philosophy at the University, and for some time before that, Lecturer in the same subject. He had been for some time in delicate health, but not dangerously ill, and had been recommended to take a trip to Europe, for the purpose of recovering his health, and of gathering ideas. He had been connected with the Society for a number of years as a Member of Council and contributor of several papers. It was, therefore, fitting that they should not allow his early demise—he was

but 44 years of age—to pass without making some mention or record of it. He was one of the earliest students in the University, having entered in 1861, and led a very successful career there. He went to Cambridge, where he was fairly successful, and afterwards occupied a teaching post at Cirencester College. Subsequently, he returned to Victoria, and was for some time head of Wesley College, and afterwards Lecturer and Professor of Natural Philosophy at Melbourne University. In Professor Andrew's death they had lost one of the most active members of the University, and one who took a great deal of interest in the Royal Society.

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*Thursday, November 15th.*

The President in the chair.

The PRESIDENT announced the resignation of Mr. Barnard as one of the Honorary Secretaries of the Society, owing to the pressure of other duties. Professor Spencer had been requested by the Council to act in Mr. Barnard's stead, and had acceded to the request.

On the motion of Mr. G. S. Griffiths, seconded by Mr. White, Professor Spencer was elected to the vacant post.

The Society then proceeded to the election of Honorary Members, on recommendation of the Council. Dr. Agnew, Dr. Bancroft, Hon. John Forrest, Sir James Hector, Hon. W. Macleay, and Mr. H. C. Russell, were elected. Mr. E. F. J. Love, M.A., was nominated as a member, and Mr. W. Swan, as an associate of the Society.

Mr. DENDY read a "Note on some Actinian Larvæ Parasitic on a Medusa from Port Phillip."

Mr. RUSDEN read a paper by the Rev. D. Macdonald, on "The Oceanic Languages Semitic."

On the invitation of the President, the author of the paper made some further remarks, and on the proposal of Mr. White, seconded by Mr. Rusden, a vote of thanks was accorded to him.

The PRESIDENT exhibited specimens of materials which had been subjected to tests in the testing machine at the University.

Notices of re-appointment of Committees were given by Mr. White and Mr. Rusden.

*Thursday, December 13th.*

The President in the chair.

Mr. E. F. J. Love was elected as a member, and Mr. W. Swan as associate.

The PRESIDENT announced the names of the retiring Officers and Members of Council.

Mr. A. H. S. Lucas was nominated as a Member of Council.

The HON. LIBRARIAN'S report showed that 62 new publications had been added to the library. The catalogue had been completed.

Mr. RUSDEN gave notice of motion, for the Annual Meeting in March, of some verbal alterations in the Rules.

Professor MASSON read a paper on "The Preparation of Alkyl-sulphine and Alkyl-phosphonium Salts," by himself and Mr. J. B. Kirkland.

A discussion ensued in which Messrs. Marks, A. H. Jackson, J. B. Kirkland, Professor Masson, and the President took part.

The PRESIDENT read a letter from Mr. Culcheth, C.E., respecting the discontinuance of the publication of the Weather Chart in the daily paper. The matter was referred to Mr. Ellery.

Mr. JAMES STIRLING, F.G.S., read a paper on "The Physiography of the Western Portion of the County of Croajingolong."

A discussion ensued in which the President, Professor Spencer, Mr. Marks, and Mr. Stirling took part.

Mr. STIRLING suggested that the delegates of the Royal Society to the Australasian Association for the Advancement of Science, should advocate the sending of invitations to attend the next meeting to delegates of the principal Universities in other parts of the world. It was decided that it was better for Mr. Stirling to move in the matter in the Council of the Association.

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| Naturhistorische Gesellschaft ... ... | ... Hanover |
| Naturhistorisches Museum ... ... | Hamburg |
| Naturhistorisches Museum .. ... | ... Hanover |
| Naturwissenschaftlicher Verein ... ... | ... Bremen |
| Naturwissenschaftlicher Verein ... ... | Frankfurt |
| Oberhessische Gesellschaft für Natur & Heilkunde | ... Giessen |
| Schlesische Gesellschaft für Vaterländ. Cultur. | ... Breslau |
| Verein für Elkunde ... ... ... | Darmstadt |
| Verein für Erdkunde ... ... ... | ... Halle |
| Verein für Naturkunde ... ... ... | ... Kassel |

AUSTRIA.

| | |
|---|---|
| K. K. Akademie der Wissenschaften ... | ... Wien |
| K. K. Geologische Reichsanstalt ... ... | ... Wien |
| K. K. Geographische Gesellschaft ... ... | ... Wien |

K. K. Naturhistorisches Hofmuseum ... ... Wien
Imperial Observatory ... ... ... ... Prague

SWITZERLAND.

Geographische Gesellschaft ... ... ... Berne
Geogr. Commerc. Gesellschaft ... ... St. Gallen
Geogr. Commerc. Gesellschaft ... ... ... Aarau
Schweizerische Naturforschende Gesellschaft ... Berne
Société de Physique et d'Histoire Naturelle ... ... Genève

FRANCE.

Académie des Sciences et Belles-Lettres et Arts ... Lyon
Feuilles des Jeunes Naturalists ... ... ... Paris
Société Académique Indo—Chinoise ... ... Paris
Société de Géographie ... ... ... ... Paris
Société Zoologique de France ... ... ... Paris
Société Nationale de Cherbourg ... ... Cherbourg

ITALY.

Biblioteca Nazionale Centrale Vittorio Emanuele ... Roma
British and American Archæological Society ... Rome
Museo di Zoologia ed Anatomia Comp., R. Universitá Torino
Ministero dei Lavori Pubblici ... ... ... Roma
Reale Academia di Scienze ... ... ... Palermo
Reale Academia di Scienze, Lettere ed Arti ... ... Lucca
Regia Academia di Scienze, Lettere ed Arti ... ... Modina
Societá Geografica Italiana ... ... ... Roma
Societá Toscana di Scienze Naturali ... ... Pisa

SPAIN AND PORTUGAL.

Real Academia de Ciencias Exactas, Fisicas y Naturales Madrid
Sociedade de Geographia ... ... ... Lisbon

HOLLAND AND BELGIUM.

Académie Royale de Belgique ... ... Bruxelles
Bataviaasch Genootschap van Kunsten en Weten-
schappen ... ... ... ... ... Batavia
Natural Science Society ... ... ... Amsterdam
Natuurkundig Genootschap ... ... Groningen

| | |
|---|---|
| Nederlandisch Botan. Vereeinging ... ... | Nijmegen |
| Magnetical and Meteorological Observatory ... | .. Batavia |
| Société Hollandaise des Sciences ... ... | ... Haarlem |
| Société Macologique Royal de Belgique ... | Bruxelles |
| Société Provinciale des Arts et Sciences ... | . . Utrecht |

### Denmark, Sweden, and Norway.

| | |
|---|---|
| Académie Royale ... .. ... | Copenhague |
| Kongelige Danske Videnskabernes Selskap ... | Kjobenhavn |
| Société des Sciences ... ... ... | Christiania |

### Russia and Roumania.

| | |
|---|---|
| Institut Météorologique de Roumanie ... | Bucharest |
| Jardin Botanique Impérial ... ... | St. Petersburg |
| La Société des Naturalistes de l'Université de Kazan ... | |
| Société des Naturalistes de la Nouvelle Russie ... | Odessa |
| Société des Naturalistes Kiew ... ... ... | Kiew |
| Société Impériale des Naturalistes ... ... ... | Moscow |
| Société Impériale Russe dė Géographie ... | St. Petersburg |

### India and Mauritius.

| | |
|---|---|
| Geological Survey of India ... ... ... | Calcutta |
| Madras Literary Society ... ... ... | Madras |
| Meteorological Society ... ... ... ... | Mauritius |
| Natural History Society ... ... ... | Bombay |
| Royal Bengal Asiatic Society ... ... ... | Calcutta |

### China and Japan.

| | |
|---|---|
| Astronomical Observatory ... ... | Hong Kong |
| China Branch of the Royal Asiatic Society ... | ... Shanghai |
| Imperial University ... ... ... | Tokio |
| Seismological Society of Japan ... ... .. | Tokio |

### Canada.

| | |
|---|---|
| Canadian Institute ... ... ... ... | Toronto |
| Geological and Natural History Survey of Canada | ... Ottawa |
| Royal Society of Canada ... .. ... | ... Montreal |

### United States.

| | |
|---|---|
| Academy of Natural Sciences ... ... | Davenport |
| Academy of Natural Sciences ... ... | Philadelphia |
| Academy of Sciences ... ... ... | San Francisco |
| American Academy of Arts and Sciences ... | ... Boston |
| American Geographical Society ... ... | New York |
| American Philosophical Society ... ... | Philadelphia |
| Bureau of Ethnology ... ... ... | Washington |
| Colorado Scientific Society ... ... | ... Denver |
| Cooper Union for the Advancement of Science and Art | New York |
| Denison University ... ... ... | ... Ohio |
| John Hopkins University ... ... | Baltimore |
| "Kosmos" ... ... ... ... | San Francisco |
| Maryland Historical Society ... ... | Baltimore |
| Natural Academy of Sciences ... ... | Washington |
| Office of Chief of Engineers, U.S. Army ... | Washington |
| Philosophical Society ... .. ... | Washington |
| "Science" ... ... ... ... | New York |
| Smithsonian Institute ... ... ... | Washington |
| Society of Natural History ... ... | ... Boston |
| Society of Natural Sciences ... ... | ... Buffalo |
| United States Geological Survey ... ... | Washington |

### Mexico.

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|---|---|
| Ministerio de Fomento ... ... ... | ... Mexico |
| Observatorio Meteorologico, Magnetico Central | ... Mexico |
| Observatorio Astronomico National ... | ...Tatubaya |
| Sociedad de Ingenieros de Jalisco ... ... | Guadalajara |
| Secretaria de Fomento ... ... ... | Guatemala |

### Argentine Republic.

| | |
|---|---|
| Academia de Ciencias ... ... ... | ... Cordoba |

### Australasia.—Victoria.

| | |
|---|---|
| "Age" ... ... ... ... | Melbourne |
| "Argus" ... ... ... ... | Melbourne |
| Athenæum ... ... ... ... | Melbourne |
| Astronomical Observatory ... ... | Melbourne |
| Australian Health Society ... ... | Melbourne |
| "Australian Journal of Pharmacy" ... | Melbourne |
| Chief Secretary's Office .. ... ... | Melbourne |
| Department of Mines and Water Supply ... | Melbourne |

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|---|---|
| Eclectic Association of Victoria ... ... | Melbourne |
| Field Naturalists' Club of Victoria... ... | Melbourne |
| Free Library ... ... ... ... | ... Echuca |
| Free Library ... ... ... ... | ... Geelong |
| Free Library ... ... ... ... | Sandhurst |
| Geological Society of Australasia ... ... | Melbourne |
| German Association ... ... ... | Melbourne |
| Medical Society ... ... ... | Melbourne |
| Parliamentary Library ... ... ... | Melbourne |
| Pharmaceutical Society of Australasia ... | Melbourne |
| Public Library ... ... ... | Melbourne |
| Office of the Government Statist ... ... | Melbourne |
| Railway Library ... ... ... | Melbourne |
| Royal Geographical Society ... ... | Melbourne |
| School of Mines ... ... ... | ... Ballarat |
| School of Mines ... ... ... | Castlemaine |
| School of Mines ... ... ... | Sandhurst |
| University Library ... ... ... | Melbourne |
| Victorian Chamber of Commerce (Manufactures) | Melbourne |
| "Victorian Engineer" ... ... ... | Melbourne |
| "Victorian Government Gazette" ... ... | Melbourne |
| Victorian Institute of Surveyors ... ... | Melbourne |

### New South Wales.

| | |
|---|---|
| Australian Museum ... ... ... | ... Sydney |
| Astronomical Observatory ... ... | ... Sydney |
| Linnæan Society of New South Wales ... | ... Sydney |
| Parliamentary Library ... ... ... | ... Sydney |
| Public Library ... ... ... | ... Sydney |
| Royal Geographical Society ... ... | ... Sydney |
| Royal Society ... ... ... | ... Sydney |
| Technological Museum ... ... ... | ... Sydney |

### South Australia.

| | |
|---|---|
| Parliamentary Library ... ... ... | ... Adelaide |
| Public Library and Museum ... ... | ... Adelaide |
| Royal Society of South Australia ... ... | ... Adelaide |

### Queensland.

| | |
|---|---|
| Parliamentary Library ... ... ... | ... Brisbane |
| Public Library ... ... ... ... | ... Brisbane |
| Royal Geographical Society ... ... | ... Brisbane |
| Royal Society of Queensland .. ... | ... Brisbane |

### Tasmania.

| | |
|---|---|
| Parliamentary Library ... ... ... ... | Hobart |
| Public Library ... ... ... ... ... | Hobart |
| Royal Society of Tasmania ... ... ... | Hobart |

### New Zealand.

| | |
|---|---|
| Auckland Institute and Museum ... ... | Auckland |
| Colonial Museum and Geological Survey Department | Wellington |
| New Zealand Institute ... ... ... | Wellington |
| Otago Institute ... ... ... | ... Dunedin |
| Parliamentary Library ... ... ... | Wellington |
| Public Library ... ... ... | Wellington |

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